S. P. Wilkinson

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B. BARNES and W. C. MOORE

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NEW RECORDS AND OBSERVATIONS. III

By A. A. PEARSON, F.L.S.

(With Plates IX–XII)

Most of the species recorded in the present paper were collected during the war years. They recall many pleasant forays in the woods of Surrey, Sussex and Hampshire within easy reach of Haslemere, in the genial company of my friend Mr E. W. Swanton. During these years of grim memories, we were collecting for medical research, and some of the first results of our efforts may be read in the paper by Drs W. H. Wilkins and G. C. M. Harris in the *Annals of Applied Biology*, vol. xxxi, pp. 262–70.

Other species are included which were sent by correspondents from various parts of Britain, whose activities are much appreciated though sometimes too overwhelming for comfort. One particularly good hunting ground proved to be Braunton Burrows, North Devon, already famous for its flowering plants.

I am much indebted to Miss E. M. Wakefield and Dr R. W. G. Dennis for so successfully portraying the four species on the two coloured plates, and for their help and criticism. Thanks are also due to Major Maxwell Knight, Mr F. Ballard and Mr Colin G. Fletcher for their excellent photographs. In work of this kind, it is indispensable to consult mycological books that are to be found in few libraries, and I must express my gratitude at being allowed the free use of the library at the Herbarium, Royal Botanic Gardens, Kew.

Amanita pantherina DC. *forma* **robusta** n.f.

Pileus 8–9 cm. wide, convex, slightly gibbous, fleshy, dull brown (tawny olive, Ridgway) with darker streaks, viscid, polished, smooth, with remains of white veil in rather large irregular patches adhering to surface and appendiculate to the margin which is incurved and more or less striate. *Gills* free, crowded, broadly linear or arcuate, blunt in front, narrowed behind, white, edge smooth or slightly fimbriate. *Stem* 10 cm. long, 1·5–2 cm. diam., attenuated above, firm, solid then hollow, white, fibrillose below, with clear-cut marginate bulb; one ring half-way up, another just above bulb which shows further traces of ring markings. *Flesh* white, unchangeable. *Taste* mild. *Smell* none when fresh. *Spore powder* white. *Spores* non-amyloid, broadly elliptical with granular contents $11–13 \times 8{\cdot}9\,\mu$.

Habitat: open space of wood in grass near birches, on chalk soil. Near East Dean, Sussex, 22 September 1943. Numerous specimens present.

This handsome, thick-set agaric is so different from the relatively slender type which in Britain has been associated with this species that it

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deserves a distinctive name. For the present it should suffice to call it forma *robusta*. A very closely allied form, equally robust, has been described by Gilbert as *Amanita abietum* (Konrad & Maublanc, *Ic. Sel. Fung.* I, Pl. 7 (1926)), which differs from the above in its habitat under conifers and the non-striate margin of the pileus.

Lepiota pseudo-felina Lange, *Dansk Bot. Ark.* IX, no. 6, 63 (1938) and *Fl. Ag. Dan.* I, 30, Pl. 12, fig. C (1935).

Pileus 1–2·5 cm. fleshy in centre, campanulate then spreading with prominent obtuse umbo, brownish black in centre, thinning out towards margin into small blackish squamules, showing white flesh underneath. *Gills* not crowded, ventricose, free, white, edge smooth or fimbriate. *Stem* white with striate fibrils, rufescent, sheathed two-thirds up and with scattered small black scales but no well-formed ring. *Flesh* white in pileus and in the pith-like centre of stem, horny brown at the sides. *Smell* mealy. *Taste* mild but rather rancid. *Spore powder* white. *Spores* amyloid, turning reddish in iodine, truncate, spurred, mostly $8·5 \times 3·5\,\mu$ (Lange's measurements $9–10·75 \times 3·25–4\,\mu$). *Gill edge* sterile with closely packed cylindrical or ventricose rather thick-walled *cystidia*, often in bunches 8–9 μ wide. *Hairs on cap* obtuse or lanceolate of different lengths 10–16 μ wide, black or only faintly tinted grey.

Habitat: in a troop under elm trees, 22 November 1945. Sent by Dr F. R. Elliston Wright from Braunton, N. Devon.

Our specimens were larger and more robust than *L. felina* (Pers.) Fr., unlike the smaller solitary specimen originally found by Lange. All parts have a tendency to turn a salmon tint when rubbed.

Tricholoma ionides (Bull.) Fr. var. **obscurissima** n.var.

Pileus 3–7 cm. shallow, convex, mat, smooth or somewhat rugulose, fuliginous-violaceous, margin incurved at first, sometimes undulate. *Gills* crowded, pale buff, emarginate, linear or ventricose, edge smooth. *Stem* 4–6 cm. long, 5–7 mm. thick, slightly paler than cap, striate, equal or with bulbous base, solid or hollow, white tomentum at base. *Smell* none. *Taste* rancid. *Flesh* horny colour. *Spores* in mass white, elongate-elliptical $5–6 \times 3–3·5\,\mu$ with or without guttules, non-amyloid. *Cystidia* absent.

Habitat: in troops under pine trees, November 1944 and 1945. Witley Common, Surrey. It is much the colour of the pine needles and easily overlooked. At first sight it may be taken for *Tricholoma melaleucum* and has probably been passed over as a form of this protean species. It was seen in troops of a dozen or so, but not caespitose.

LATIN DIAGNOSIS. *Tricholoma ionides* (Bull.) Fr. var. *obscurissima* Pearson. *A typo differt colore pilei et stipitis violaceo-fuligineo; colore lamellarum pallido-luteolo; etiam caro fusca; caetera concordant.*

Mycena fellea Lange.

In a previous paper of this series (*Trans. Brit. myc. Soc.* XXVI, 39) I used this binomial rather than *M. erubescens* v. Höhnel, but I have since received a very interesting note from M. Marcel Josserand who writes that he was

once in a district where this species grew abundantly and he had the chance of seeing tens of thousands of examples growing on the mossy trunks of conifers. He found it extremely polymorphous, varying in size from 8 to 32 mm., often with a white milk as in *M. galopus*, and sometimes turning a pink or even a bright carmine.

All this confirms the opinion of Kühner that *M. fellea* is identical with *M. erubescens*, and as the epithet *erubescens* was used a year before Lange introduced his *M. fellea*, we have to accept it.

Mycena erubescens v. Höhnel = *M. fellea* Lange.

To the description given add: sometimes exuding white milk and turning reddish.

Mycena quisquiliaris (Joss.) Kühner in *Le Genre Mycena*, 388 (1938) = *Omphalia quisquiliaris* Josserand, *An. Soc. Linn. Lyon*, LXXX, 88 (1937).

Pileus usually very small, full range 1–10 mm. membranaceous, white, fragile, convex or umbilicate, rarely papillate, when old sulcate with crenulate margin, dry, pubescent. *Gills* few, distant but not pliciform, white, adnate, linear or arcuate, edge denticulate seen under strong lens. *Stem* very thin thread-like, usually short, straight or curved, hyaline-white, pubescent, base often with minute pubescent bulb. *Basidia* four-spored. *Spores* amyloid; obovate, tear-shaped or subfusiform, smooth 11–13 × 4–6 μ. *Cystidia* on gill edge ventricose with blunt apex often capitate and sometimes forked 30–70 × 7–13 μ. *Cuticle* of pileus and stem with numerous cylindrical capitate or subglobose cells.

Habitat: in troops on dead debris of marsh plants especially of *Molinia caerulea*, but also recorded on *Carex* sp. and *Rubus*. Collected by Mr E. A. Ellis on *Cladium* at Wheatfen, December 1942.

This small agaric is probably very common. It is said sometimes to occur in vast numbers on *Molinia*. Doubtless it has escaped being recorded on account of its small size and fragility. The cap may be as small as a pin's head, but larger specimens occur and in a glass tube will keep for days. Specimens will usually be found not on the surface but underneath a pile of debris where the moist atmosphere enables it to flourish.

Mycena arcangeliana Bres. var. *Oortiana* Kühner, *Le Genre Mycena*, 297 (1938). *De Nederl. Myc.* A. S. P. Oort, 229 (1928).

Pileus 1–1·5 cm. obtusely conical, at first greyish brown, then white with a very slight olive tint, striate sulcate half-way to centre. *Gills* crowded, adnexed, attenuated towards stem, white then pinkish, edge fimbriate. *Stem* 2–4 cm. long, 1–1·5 mm. thick, cylindrical, polished, lilaceous grey, darker when young, tomentose at base, hollow. *Flesh* white in cap, grey in stem. *Smell* strong of iodoform. *Taste* mild. *Basidia* four-spored. *Gill edge* sterile with closely packed club-shaped or pyriform warted cystidia mostly 12–14 μ wide. *Spore powder* white. *Spores* elliptical 7–8 × 4·5–5 μ one guttulate, smooth, amyloid.

Habitat: caespitose on rotting elder (*Sambucus Ebulus*). Collected by Dr R. W. G. Dennis at Mickleham, Surrey, 15 October 1945. On Pl. IX D, Dr Dennis has provided an excellent drawing of his specimens.

The above description corresponds closely to that given by Oort, his range of size being larger: pileus 1–2·5 cm., stem 3·5–10 cm. long, 1–3 mm. thick. He recorded his specimens as *Mycena arcangeliana* Bres., but Kühner made it into a variety though he might well have given it specific rank, since it differs in many respects from the description given by Bresadola in *Bull. Soc. bot. it.* 78 (1904). The smell in the type species is strong '*fere carnis assatae*' which Kühner translates as 'chair brûlée', though it may well mean roasted meat rather than burnt flesh; the habitat is on a palm stem.

The iodoform smell and warted cystidia place *M. Oortiana* in a well-defined group of *Mycena*, the commonest species of which we usually call *M. metata*, but which Kühner effectually disguises under the name of *M. vitrea* var. *tenella*.

Omphalia Mairei Gilbert, *Bull. Soc. Myc. Fr.* XLII, 63 (1926) and Josserand, *Soc. Linn. Lyon*, LXXX, 14 (1937).

Pileus 5–15 mm. thin, convex soon expanding, striate by transparence, whitish or greyish hyaline. *Gills* few and distant, fairly wide and rather thick, sometimes anastomosing, arcuate, decurrent or subdecurrent, edge blunt and smooth. *Stem* filiform 2–3 cm. long, equal or thickened above, white hyaline, smooth. *Smell* of new meal or none. *Taste* mild. *Basidia* with four sterigmata. *Cystidia* absent. *Spores* in mass, white, boat-shaped or virguliform, usually pointed at both ends, but some are round at one end, with or without guttule, mostly $8 \times 4{\cdot}5\,\mu$ in specimens examined ($7–9 \times 3–4\,\mu$ Gilbert. $8–9{\cdot}5 \times 4–4{\cdot}8\,\mu$ Josserand), non-amyloid.

Habitat: in quantity on bank of wet ditch. Haslemere, August and October 1944. Also by Dr F. N. Elliston Wright in sandy soil among dunes, Braunton Burrows, 30 October 1944. Probably common.

Two other species of *Omphalia* have spores similar to the above: *O. integrella* Fr. has narrow, often vein-like gills and amyloid spores. *O. candida* Bres. is caespitose on dead rhizomes of comfrey, has a long stem and deeply decurrent gills.

Marasmius oreadoides (Pass.) Fr., Passerini, *Fungi Parmensi*, in *Nuovo Gior. Bot. It.*, 109 (1872). Saccardo, *Fl. It. Crypt.* Pars 1, *Fungi*, 470.

Pileus 2–5 cm. densely caespitose, somewhat fleshy, convex or flat but very irregular in outline with contorted folds, smooth, mat, whitish or pinkish buff with brick-coloured patches when old, margin incurved at first. *Gills* distant, white or cream, of various shapes and sizes, broad or narrow, linear or ventricose, mostly free. *Stem* 3–5 cm. long, 4–10 mm. wide, confluent with pileus, compressed, striate with silky pruinose fibrils, white, hollow, mostly with acuminate base and often with white tomentum at base. All parts elastic. *Flesh* very pale buff. *Smell* pleasant. *Taste* rather bitter after mastication. *Spores* white in mass, subfusiform (cylindric apiculate) $6–6{\cdot}5 \times 2{\cdot}5–3\,\mu$. *Cystidia* absent.

Habitat: collected by Mr R. H. Johnston at Ballock Park, southern end of Loch Lomond, Scotland. Growing luxuriantly on heap of old leaves, 3 and 10 October 1944.

The only doubt I have in assigning this to *M. oreadoides* is that Saccardo gives the spores as '*ellipsoideus* 6 × 3–3·5 *basi vix apiculatus*' whereas our specimens had distinctly apiculate spores.

Hygrophorus (*Limacium*) *leucophaeus* (Scop.) Fr. = *H. discoideus* Quél. non Fr.

A slender species, all parts flesh-pink.

Pileus 2·5–5 cm. very viscid, fleshy in centre, flat or with small umbo, soon depressed and upturned, delicate flesh-pink, darker in centre, glabrous. *Gills* subdistant, ventricose, decurrent or adnate with decurrent tooth, pale flesh-pink. *Stem* 3–5 cm. long, 4–5 mm. thick, flexuose, usually tapering to a point, a little darker than pileus, paler above, fibrillose-floccose, solid. *Flesh* concolorous. *Taste* mild. *Smell* none. *Spores* in mass, white, elliptical 6·5–7 × 4–5 μ.

Habitat: in beech woods. East Dean Park, Sussex, 30 October 1944. Elsewhere we collected a very pale form with smaller spores, but further observations are necessary to ascertain if this deserves varietal rank.

H. leucophaeus is often confused with *H. discoideus* (Pers.) Fr. which is more robust, rusty ochraceous and grows in pine woods. This latter species has been illustrated by Cooke, *Ill.* 887 (914) as *H. mesotephrus* B. & Br.

Since the above was written, we have seen vol. v of J. Lange's *Flora Agaricina Danica*, where on Pl. 163 both the typical and paler forms are illustrated, the latter being distinguished as a variety but without epithet. It can be left at that till further investigated.

Russula luteo-viridans Martin, *Bull. Soc. Bot. de Genève*, VII (1894).

Pileus 3–10 cm. wide, convex then depressed in centre, viscid, smooth except margin which is striate-tuberculate, shining greasy looking, pallid greenish buff with tinge of red towards margin; cuticle peels half-way. *Gills* crowded, edge smooth and thin, thick at base, rounded in front, attenuating to stem, attached by slight emargination, colour when mature orange buff, all one size or anastomosing at margin of pileus. *Stem* 3–5 cm. long, 3 cm. wide, cylindrical, firm at first soon soft with spongy stuffing, white, finely rugulose. *Flesh* white. *Smell* none. *Taste* rather acrid. *Chemical reactions:* Phenol: pink then dark purple. Ferrous sulphate: none at first, then greyish. *Spore powder* G. of Crawshay (light orange yellow). *Spores* amyloid, broadly ovate with long coarse warts 9·5 × 7 μ without reticulation. *Cystidia* on gill edge sparse, lanceolate, staining throughout dark blue with sulphovanillin 50–70 × 8–11 μ. *Cuticle* of cap also with cystidia as above but longer and narrower than on gill.

Habitat: under oak. Jays Wood, near Gospel Green, Sussex, 9 August 1945.

This seems to be a rare species. Only one example was seen, but so exactly coinciding with the description given by J. Schaeffer in his *Russula Monographie*, p. 504, that I have no hesitation in recording it. On the Continent it has been reported as growing under spruce, fir and hornbeam. No good illustration of this species has yet been published. There is some doubt whether it is distinct from *R. urens* Romell.

Since writing the above, Romagnesi in *Bull. Soc. Myc. Fr.* LVIII, 167 (1942), has described a *R. luteo-viridans* which seems to agree with our

fungus except that no cystidia are present in the cuticle of pileus as stated above and also in Schaeffer's description. In the French specimens there are long hyphae filled with granular matter but no genuine dermatocystidia.

Pluteus Godeyi Gillet, *Champignons de France*, 395 (1874).

Pileus 1–4 cm. usually small, membranaceous, convex, slightly umbonate, bluish grey or with slight pink tinge from the gills beneath, translucently striate at margin. *Gills* subdistant, broad, ventricose, free, watery white then pink. *Stem* short, straight or curved, smoky white or bluish grey, striately fibrillose, base not or very slightly swollen. *Basidia* four-spored. *Spores* pinkish, broadly elliptical, smooth with granular contents 7–8 × 5–6 μ. *Cystidia* bladder-shaped of varied dimensions 25–40 × 8–20 μ. *Cuticle* of pileus hymeniform with subglobose cells.

Habitat: on the ground in frondose woods. Collected by Mr E. A. Ellis at Wheatfen, 1 October 1942.

We follow Lange in naming this small agaric, which was described by Gillet from a sketch made by Godey. It is closely related to *Pluteus semibulbosus* which is characterized by the powdery surface of the pileus and very large cystidia.

Flammula flava (Bres.) Lange, *Fl. Ag. Dan.* IV, 12, Pl. 123, fig. G (1939).
Naucoria flava Bresadola, *Ann. Myc.* III (1905) and *Icon. Myc.* tab. 795.
Flammula dactylidicola J. E. Lange in *Dansk Bot. Ark.* V, no. 7, 6 (1928).

Pileus usually small, full range 1–5 cm., fleshy, convex then gibbous or umbonate, margin incurved then straight, pale ochre when young turning to a deeper rust colour, the dry surface slightly tomentose. *Gills* crowded, pale lemon yellow then rusty, broad, arcuate or ventricose, emarginate with decurrent tooth, edge pallid and minutely denticulate under a lens. *Stem* 2–5 cm. long, 3–10 mm. diam. solid or with hollow base, fibrillosely striate, apex pruinose, pale yellow becoming rusty, slightly swollen below with fusiform base. *Flesh* soft, pale yellow. *Smell and taste* not specially noticeable. *Basidia* with four sterigmata. *Spores* ferruginous in mass, broadly ovate, indistinctly apiculate, minutely verrucose and sometimes one-guttulate, 4·5–5·5 × 3·5–3·75 μ. *Cystidia* on gill edge in crowded groups, filiform capitate with base slightly swollen 25–30 × 4–5 μ.

Habitat: in tufts of cock's-foot grass (*Dactylis glomerata*), two or three together but not caespitose. Collected by Mr G. J. Cooke at Lakenham Hall, Norwich, 29 August 1942, in an old overgrown orchard under a medlar tree.

This species is said to be not uncommon in Denmark but has been overlooked in this country probably because it is hidden at the base of grass stems. Lange usually found it attached to cock's-foot grass 'even in a mixed vegetation of more than ten species of grass, it was found exclusively on the *Dactylis* tufts'.

Galera appendiculata Lange & Kühner in *Le Genre Galera*, R. Kühner, 146 (1935) and *Fl. Ag. Dan.* J. E. Lange, IV, 36, Pl. 159, fig. A (1939).

Pileus 1–1·5 cm. convex then almost flat, umbonate or papillate,

ochraceous then pale buff, pulverulent, striate half-way or at margin, fugacious white veil appendiculate to margin in fragments. *Gills* crowded, adnate or almost free, ventricose or linear, cream at first, edge white and fimbriate. *Stem* 4–4·5 cm. long, 1·5–2 mm. thick, striate with white silky fibrils, pale honey below, pruinose above, slightly swollen at apex, base slightly bulbous covered with white pubescence. *Flesh* honey colour. *Basidia* four-spored. *Spores* in mass antique brown (Ridgway), elliptical, smooth with granular content 7–8 × 4·5–5 μ. *Cystidia* abundant on gill edge, bottle-shaped with obtuse apex 25–45 μ long. *Cuticle* of cap hymeniform with cells 12–20 μ wide.

Habitat: waysides on naked soil or amongst grass in shady places. Found under hazel at Pewley Hill, Guildford, Surrey, 7 October 1942.

Not common but may be overlooked as the pendant marginal veil soon disappears, when it is not so easy to determine.

Galera ravida Fr. also has a marginal veil, but appears to be a more robust fleshy species.

G. appendiculata belongs to the section *Pholiotina* which includes species having a hymeniform cuticle of the pileus and no capitate skittle-shaped cystidia. In this section Kühner also includes several small species of *Pholiota*, but this is rather confusing.

Cortinarius (Inoloma) rubicundulus (Rea) n.comb., *Flammula rubicundula* Rea, *Grev.* XXII, 40, Pl. 185, fig. 2 (1894). *Cortinarius* (*Inoloma*) *pseudobolaris* R. Maire in *Cort. d'Eur.* (Bataille, 1912) and *Ann. Myc.* XI, 346 (1913). *Cortinarius* (*Telam.*) *limonius* Quél. non Fr. *Fl. Myc.* 139 (1888).

Pileus 4–8 cm. convex then expanded, margin incurved, aspect glabrous but *sub lente* with small innate scales, yellowish turning saffron red when touched; margin often showing remnants of veil which at first is white, then reddens. *Gills* fairly crowded, rather thick, linear or arcuate, adnate or with a decurrent tooth, often separating from stem, light ochre then cinnamon; edge smooth, at first pallid then saffron red. *Stem* 3–8 cm. long, 0·5–1 cm. thick, solid then hollow, cylindrical or with subbulbous base or sometimes with attenuated base, fibrillose striate, sometimes with minute granules forming a net at the apex. The white veil often forms a clear-cut zone or ring above this. *Flesh* cream, then yellowish, finally saffron. *Smell* faint. *Taste* mild or slightly bitter and acrid after mastication. *Spores* in mass milky coffee (antique brown: Ridgway), boat-shaped or subfusiform, very minutely punctate, 1–2 guttulate, 7–10 × 4–4·5 μ. *Cystidia* on gill edge sparse fusiform 45–65 × 7–9 μ.

Habitat: on the ground in deciduous woods. Rare.

Good illustrations of this species are in *Bull. Soc. Myc. Fr.* XXXIX, Pl. VII, together with *C. bolaris* Fr. with which doubtless it is sometimes confused.

Cortinarius (*Hydrocybe*) *holophaeus* Lange in *Dansk Bot. Ark.* VIII, no. 7 (1935) and *Fl. Ag. Dan.* III, 45, Pl. 102, fig. C (1938).

Pileus 5–6·5 cm. convex, flat or with shallow umbo, hygrophanous, dark reddish brown often with black blotches or zones, deep buff when dry, covered with white veil when young which persists at margin in older

specimens. *Gills* distant, rather broad, adnate, ventricose, emarginate, edge smooth. *Stem* 4–7 cm. long, 1 cm. wide, striate with pallid silky fibrils, cartilaginous outside but with soft substance inside which soon rots; base swollen, sometimes oblique and covered with a white pubescence. *Flesh* brown. *Smell* and *taste* not distinct. *Basidia* four-spored. *Spores* in mass between amber and Sudan brown (Ridgway), ellipsoid sub-amygdaliform with granular contents, 8–9 × 5–5·5 μ smooth. The spores vary from elliptical to more distinctly almond-shaped.

Habitat: in beech woods. Found in Singleton Forest, Sussex, 9 October 1943.

Said to be rather rare, but probably one of the species we are apt to dismiss as *C. brunneus* which is sometimes found with the ring not clearly defined and has been variously interpreted.

Cortinarius (Telamonia) ammophilus n.sp. Pl. IX B.

Pileus 7–20 mm. conical then plane with persistent acute or obtuse umbo; fleshy; snuff brown umbo darker; rimose, sometimes breaking up into scales; margin regular, brown veil usually adhering to margin. *Gills* distant in three lengths, broad, ventricose, deeply emarginate, sometimes with anastomosing veins, edge blunt and smooth, somewhat wavy; light cinnamon at first. *Stem* 1–2·5 cm. long, slender or thick 1–3 mm. solid with a loose fibrous stuffing then hollow; at first with striate fibrils then brown; peronate; ring brown usually present, median or two-thirds up. *Flesh* white in pileus, with purplish tint in stem. *Smell* not distinct. *Taste* mild. *Spores* brown, elliptical, smooth, 8·5–11 × 4·5–5·5 μ. *Cystidia* absent.

Habitat: in flat damp parts of sand dunes under *Salix repens*. Braunton Burrows, north Devon. October and November 1945, in troops. Collected by Dr F. R. Elliston Wright.

Differs from small conical species in the *Telamonia* group by its rimose cap, distant gills and purplish flesh. From the large quantities gathered, it may not be rare in sand dunes.

Type specimens: at the Herbarium, Royal Botanic Gardens, Kew. The figures on Pl. IX are by Dr R. W. G. Dennis. *Cortinarius* does not travel well and the specimens were not in their pristine colouring.

LATIN DIAGNOSIS: *Cortinarius* (*Telamonia*) *ammophilus* Pearson. *Pileus carnosulus, umbrinus, rimosus vel interdum squamulosus e conico explanatus 7–20 cm. latus, umbone obscuriore, acuto vel obtuso, margine regulari, saepe cortina umbrina ornato. Lamellae valde distantes, latae, ventricose, postice eximie emarginatae, saepe venosae, cinnamomeo-ferrugineae, acie obtusa vel levi, aliquantulum undata. Stipes 1–2·5 cm. longus, tenuis vel crassus 1–3 mm., laxe farctus, albus vel brunneus, fibrillis sericeis striatus, peronatus, annulo medio vel supero persistente. Caro pilei alba, stipitis dilute purpureo tincta, odore subnullo, sapore dulcidulo. Sporae ochraceae ellipsoideae leves 8·5–11 × 4·5–5·5 μ. Cystidia nulla.*

Habitat: catervatim, locis humidis, in terra arenosa prope mare.

Inocybe (*Astrosporina*) *striata* Bres. *Icon. Myc.* Pl. 759 (1930).

Pileus 7–10 cm. convex-plane with prominent pointed umbo, fleshy in centre, ridged at incurved margin, rimose then shaggy with adpressed or

upturned scales, almost smooth in centre, umber brown, almost black on umbo, paler towards margin. *Gills* subdistant, short ones near margin, somewhat narrow linear, adnate then free, whitish at first then colour of spores; edge white, fimbriate often spotted brown wavy. *Stem* 6–8 cm. long, 1–2 cm. thick, flabby with loose fibrous stuffing or hollow, striate with fibrils then shaggy, umber brown darker near base which is equal or slightly swollen. *Flesh* white in cap, pallid in centre of stem, brown near surface. *Smell* none. *Taste* rather rancid. *Spores* in mass, dilute snuff or tawny olive, nodulose, oblong 7–8 × 5–6 μ with five to six prominent nodules in outline. The spores are lighter in colour than in most species of *Inocybe*. *Cystidia* crowded on gill edge, sparse on face, fusoid ventricose with or without crested apex, 60–80 × 14–18 μ.

Habitat: on sandy bank, near pine, birch and oak. Hindhead, Surrey, 23 September 1942.

Differs from Bresadola's diagnosis in larger size and somewhat smaller spores but differences would hardly justify a new specific designation.

Inocybe Langei Heim in *Le Genre Inocybe*, 335, Pl. IX, fig. 1 (1931). J. Lange, *Fl. Ag. Dan.* III, 78, Pl. 113, fig. F (1938).

Pileus 1–2·5 cm. convex then expanded usually with shallow umbo, pale buff or with slight pink tint, margin white, darker with age, rimose fibrillose, incurved margin shaggy and cracking. *Gills* subdistant, ventricose, rather broad, adnexed narrowly emarginate, white at first, then ochraceous with olive tinge, edge white and minutely fimbriate. *Stem* usually short, 2–4 cm. long, 4–6 mm. thick, white or flushed with pale pink, striate, pruinose above, solid, sometimes with bulbous base. *Flesh* white or with pink flush. *Smell* of new meal. *Spores* in mass snuff brown, elliptical, flat one side or almond-shaped smooth 7–8 × 4·5–5 μ. *Cystidia* mostly short and broadly ventricose, apex blunt without neck or a very short one, usually crested 36–50 × 14–17 μ.

Habitat: on bare ground. Growing in troops under laurel hedge. Hindhead, Surrey, 2 April 1942.

This small stubby *Inocybe* belongs to the series that may be described as satellites of *I. tomentosa* (Jungh.) Quél. better known as *I. eutheles* B. & Br. all of which are pale buff strongly smelling of new meal. The separate identity of these is not easy to determine, and one has largely to decide on the size and shape of spores and cystidia. *I. Langei* has short stout blunt cystidia. The spores vary in their outline, both ends being either round or pointed.

The small *Inocybe* described and figured by Bulliard as *Agaricus lanuginosus* has erect hairs on the pileus and its habitat is on or around dead stumps. Another and larger *Inocybe* is also commonly assigned to this species, but is distinct in many details. The smaller species should retain the epithet *lanuginosa*.

Inocybe (*Astrosporina*) *lanuginosa* (Bull) Fr., *Syst. Myc.* (1821) = *Inocybe ovatocystis* Kühner & Boursier in *Bull. Soc. Myc. Fr.* XLIV, 181 (1928).

Pileus small 1–2 cm. wide, convex then flat, dark snuff brown, densely fibrillose with squarrose pointed scales in centre. *Gills* crowded, ventricose,

cream then brown with white fimbriate edge. *Stem* slender 3–4 cm. long, 2·5–3 mm. wide, cylindrical or flexuose, slightly swollen below, covered with rather shaggy fibrils, brown above, blackish brown below. *Flesh* white, turning brown at base of stem. *Smell* earthy. *Taste* mild slightly rancid. *Spore powder* snuff brown. *Spores* nodulose, with rough ovate or oblong outline, numerous conical warts and rather larger apical wart, mostly 8–8·5 × 5–5·5 μ. *Cystidia* in tufts, ovate or pyriform with a few subcapitate ones, mostly without neck or crystalloid apex 35–40 × 14–20 μ.

Habitat: on the ground. Hindhead, Surrey, round stump, September 1942. Henley, Sussex, under larch, October 1942, etc.

Not so common as the next. Cooke's figures in *Ill.* 408 (582) are more like *Inocybe dulcamara*, which doubtless is often confused with this species. His 409 (425) more nearly represents the above.

Inocybe (*Astrosporina*) *longicystis* Atk. G. F. Atkinson, *Am. J. of B.* v, 213 (1918). Kühner & Boursier, *Bull. Soc. Myc. Fr.* XLIV, 179 (1928). R. Heim, *Le Genre Inocybe*, 364 (1931) as *I. lanuginosa* forms *a* and *b*.

Pileus 3–4 cm. shaggy fibrillose with erect acute scales on disk, dark brown. *Gills* crowded, adnate, rather wide, pallid then snuff brown, with white fimbriate edge. *Stem* 4–7 cm. long, 5–6 mm. diam., cylindrical, brown with shaggy fibrils, pallid at apex, darker near base. *Flesh* white. *Smell* unpleasant. *Spore powder* snuff brown. *Spores* with oblong outline and many projecting warts, often with larger one at apex 8–10 × 5–6 μ. *Cystidia* abundant, cylindrical or slightly ventricose and subcapitate, usually without crystalloid apex, but crystals are sometimes present 60–70 × 15–17 μ.

Habitat: on the ground especially in damp woods. Fairly common. Grayswood, Surrey among sphagnum, September 1943. Rothimurchus Forest, Scotland, August 1938, and other localities.

This is fully worthy of specific rank. It is much larger in size and the cystidia are very different from those in *I. lanuginosa*. The spores are much the same as in preceding species except that the nodules are more numerous. This is only noticeable when the spores are examined together.

Inocybe serotina Peck. *Bull. N.Y. St. Mus.* 75, 17 (1904).

Pileus 1–8 cm. convex, obtusely umbonate, margin abruptly inturned at first, rimose with striate arachnoid fibrils, white turning ochre or rusty brown, splitting when old. *Gills* crowded, adnexed or free, ventricose or linear, white at first then snuff brown with a slight olive tinge and a white fimbriate rather thick edge. *Stem* 3–10 cm. long, 3–10 mm. wide, firm, solid, thickened above and below, base sometimes with a submarginate bulb, white near apex and with striate rusty fibrils below or rusty brown all over except at white base, often curved. *Flesh* white. *Smell* none or musty. *Taste* mild. *Spore powder* snuff brown. *Spores* cylindrical, smooth, 12–16 × 5–6 μ. *Cystidia* usually not crested, closely packed on sterile gill edge, subcylindrical, balloon-shaped or ventricose 40–70 × 10–14 μ; also on gill face.

Habitat: in sand dunes. Braunton Burrows, North Devon. Sent by Dr F. R. Elliston Wright, October and November 1945.

This North American species has already been recorded in the sand dunes of Holland and Denmark. It can readily be known by its oblong spores, the only other British species of *Inocybe* with cylindrical spores being the common *I. lacera*. It is very variable in size; the first gathering in October consisted of small specimens 1–2 cm. wide, but in November a robust example was collected with cap 6·5 cm. across and stem 10 cm. long.

Inocybe griseo-lilacina Lange in *Dansk Bot. Ark.* II, no. 7, 32 (1917) and in *Fl. Ag. Dan.* III, 73, Pl. 111, fig. F.

Pileus 1·5–2·5 cm., conical then flat usually with umbo but sometimes depressed in centre, margin involute at first, then straight, azure blue or lavender, disk turning brown, tomentose breaking into shaggy scales. *Gills* crowded or subdistant, white then snuff-coloured, ventricose, adnate, edge white, fimbriate. *Stem* 4–7 cm. long, 2·5–3 mm. thick, azure or lavender, densely covered with whitish flocci and fibrils, hollow but firm, cylindrical sometimes slightly swollen at base. *Flesh* azure blue or white in cap when old. *Smell* fairly strong, a blend of new meal and pelargonium. *Taste* mild. *Gill edge* sterile with thick-walled flask-shaped cystidia very varied in size and outline, with stout or slender neck, smooth or cristate apex; these are mixed with thin-walled sack-shaped cells (paracystidia) 12–20 μ wide. *Spore powder* snuff brown. *Spores* elliptical or sub-amygdaliform 8–9 × 5 μ.

Habitat: solitary, in troops or caespitose, in deciduous woods, especially on roadside where leaves have been swept. Fairly common in south of England.

It is helpful to have this defined as a species separate from the less distinguished *I. obscura* (Pers.) Fr. to which it is allied. We take *I. obscura* to be the very common and smaller agaric with a bluish tint only at the apex of the stem.

The fig. C on Pl. IX is by Miss E. M. Wakefield from specimens collected near Haslemere, Surrey.

Stropharia rugoso-annulata Farlow, *Ic. Farl.* Pl. 65 (1929), also L. O. Overholts, *Mycologia*, XXII, 243, Pl. 30 (1930).

Pileus 5–12 cm. wide, fleshy, conical subglobose or flat, margin strongly incurved at first, livid purple (near vinaceous brown of Ridgway) with yellow background, innately fibrillose and rimose, sometimes pitted with holes on disk, covered with a thin pallid pruine which disappears with rubbing; margin undulate and plicate. *Gills* up to 10 mm. broad, crowded, arcuate or broadly linear, adnate, smoky grey with white crenulate edge. *Stem* 15–17 cm. long, 1·5–3 cm. wide, solid but with loose fibrous stuffing, often narrowed at apex and abruptly broadening out to a long cylindrical stem with or without sub-bulbous base; white, washed with lemon; striate-ribbed; white tomentum at base, to which are attached white terete rhizomorphs. *Ring* superior, thick, white, tinted lemon frequently appendiculate to margin, the lower surface dividing up into large triangular segments, the upper surface fin-like, dovetailing between the gills, to

which it often remains persistently attached. When the ring is freed from the margin and the gills, it is pendulous, deeply sulcate above, smooth below with triangular segments at margin. *Flesh* white, unchangeable. *Gill edge* sterile with closely packed *cystidia* 12–16 μ wide, mostly clavate, sometimes broadly flask-shaped. *Spore powder* sooty black. *Spores* violaceous under microscope in water when fresh, the germ spore giving a somewhat truncate apex, broadly elliptical 11–13 × 6–7 μ.

Habitat: growing luxuriantly on rotting wheat straw. Woking, Surrey, September 1945. Brought to the Haslemere Museum by Miss V. Haslop. The seed was not of American origin.

Some etiolated specimens were also present, presumably having matured under the straw and looking remarkably different from the normal ones, the cap being quite flat, the colour almost white, the stem long and slender and not narrowed at the apex.

None of our specimens shed spores freely and only a sparse spore deposit could be obtained. The same experience seems to have been met with in America.

This striking species has only been recorded in recent years in the United States where it now appears to be fairly common. Its habitat there is on cultivated ground or among woody debris. The spores are variable. Farlow 11–13 × 8–9 μ; Overholts 13–15 × 8–9 μ; Rolf Singer (*in litt.*) 12–18 × 7·5–10 μ mostly 13 × 7·5–8 μ. These are rather larger than my measurements.

The fine illustrations of *S. rugoso-annulata* on Pl. IX are by Dr R. W. G. Dennis and represent a typical specimen with the veil clinging to the gills. This does not bring out the triangular fringe of the veil which is better shown in the painting by Kroeger in the *Icones Farlowianiae*.

The photographs on Pl. X are by Major Maxwell Knight, and were taken *in situ*. Fig. A shows an etiolated discoloured specimen, which looks entirely different from the type.

Psalliota vaporaria (Vitt.) J. Schaeffer, *Ann. Myc.* xxxvi, 71 (1938). Vittadini, *Fung. Mang.* tab. viii (1835) as *Agaricus campestris* Linn. var. *pratensis*, *vaporarius*. J. Lange in *Fl. Ag. Dan.* iv, 59, Pl. 140, fig. D as *P. subperonata* Lange (1939).

Pileus 3–20 cm. fleshy, subglobose, margin inturned, dark brown, like a potato skin or darker (clay colour to tawny olive of Ridgway), background white covered with long ragged innate brown scales, dense in centre, less so at margin where the white flesh is evident. *Gills* crowded, dull pink when young then blackish brown, sublinear pointed both ends, free, edge pallid, fimbriate. *Stem* stout 14 cm. long, 4 cm. thick in specimens studied, white above, brown near base, cylindrical or slightly swollen below with a few shaggy scales. *Ring* double, the lower part sometimes separating from the upper, the top one white, striate clinging to apex of stem, the lower one very thick and partly brown, sometimes with a clear space between. *Flesh* white turning reddish brown. *Smell* slight of mushroom, but very variable. *Taste* mild, nutty. *Gill edge* sterile with small clavate or capitate cells. *Spores* blackish brown, subglobose 6–7 × 5–6 μ mostly one-guttulate.

Habitat: in rich dark earth under trees by roadside. Grayswood, 28 August 1945. Collected by Dr F. Rauter.

No full description was given by Vittadini, only short explanations of the excellent figures on his plate. He clearly shows the separation of the two sections of the ring, which together with the almost globose spores, the ragged yet innately scaly pileus and the remarkably thick lower portion of the ring, make this a clearly defined species.

J. Schaeffer gives a choice of odours, from pine sawdust when fresh, to meat-gravy, liquorice and fenugreek (*Maggi*) when dry!

Psalliota xanthoderma Genevier. *Soc. Bot. de Fr.* (1876).

This species is characterized by a silky, white, smooth, truncate pileus and marginate bulbous base to the stem. It turns a fugacious lemon yellow when bruised and has white flesh except in the base of stem which is yellow. The spores are very small and the gill edge sterile with subglobose cells. It is said to have an unpleasant 'foetid' smell which has variously been interpreted as creosote, carbolic acid, ink, the urine of mice, chlorine, phenol, iodoform, etc. The smell seems to be absent in most British specimens which have come under my observation, but has been noticed by some collectors. The conditions under which this smell occurs remain to be investigated. The type has been illustrated by Konrad and Maublanc in their *Icon. Sel. Fung.* Pl. 30, but the spore measurements given are much too large and they have not indicated the sterile cells on the gill edge which is an important diagnostic feature in many mushrooms.

There are many varieties and var. *lepiotoides* Maire has already been recorded by Rea. This differs from the type in having greyish brown concentric squamules on the cap. It is found in large rings on open chalk downs, the sporophores being sometimes of massive size.

Other varieties occur in Britain, and the following is fairly common, having been collected by me in Kent, Sussex, Surrey and Yorkshire.

Psalliota xanthoderma Genev. var. *obscurata* Maire in *Bull. Soc. Myc. Fr.* XXVI, 192, also as *P. meleagris* J. Schaeffer in *Zeitschrift für Pilzkunde*, Jahrg. 4, 28 (1925).

Differs from the type in having blackish squamules, dense in the centre and more scattered towards margin. The ring usually has flocci on lower surface. It is a very elegant mushroom with its black and white ('guinea-fowl') cap and grows under deciduous trees, especially oak, on the edge of woods where there is an accumulation of leaves or road sweepings. In the *Icon. Myc.* tab. 830 Bresadola has erroneously illustrated this variety as *P. silvatica* Schaeff. The spores taken from many gatherings measure $5–5{\cdot}5 \times 3–3{\cdot}5\,\mu$ and agree with the spore deposit I obtained from a specimen named by Dr René Maire in Catalonia, Spain, in October 1935.

Another variety quite distinct from the above is var. **grisea** n.v. which differs from the type in the pale grey mat surface of the cap, which soon cracks and finally breaks up into minute squamules of the same colour. It has a ring with floccose fragments on the under surface and no smell. The spores are about $5 \times 4\,\mu$ one-guttulate.

Habitat: on chalk grassland which had been trampled over by soldiers billeted nearby; near beech woods. Goodwood, Sussex, October 1942, November 1944.

LATIN DIAGNOSIS: **Psaillota xanthoderma** Genev. var. **grisea** Pearson. *Differt pilei superficie impolito, colore griseolo, deinde in squamulis minutis griseolis diffisso, odore subnullo. Sporae late ovatae vel subglobosae leves* 5–5·5 × 4–4·5 μ *uni-guttulatae. Cellulae aciei lamellarum obovatae.*

This mushroom lacks the elegance of the other varieties and may deserve specific rank, but a more intensive study of the whole group is called for.

Psalliota villatica Brond. sensu Bres.

Pileus 5–30 cm. very fleshy, at first subconical or globose with inturned margin, then expanding to semi-globose, mat pulverulent breaking up into small or large adpressed concentric scales, white or pale buff, yellow when rubbed, very variable in colour when old, in dry sunny weather turning a golden yellow like ripe wheat, often with reddish patches, veil often hanging in ragged patches to margin. *Gills* crowded, broad or narrow; linear, ventricose or arcuate, pointed both ends, free, edge smooth, at first pallid grey, then a pinkish brown, finally blackish brown, mostly of one length many forked from stem. *Stem* robust 5–20 cm. long, 3–5 cm. thick, firm, solid, white, cylindrical or ventricose, with concentric white or brown flocci below ring when young, striate above, smooth and satiny when old when it may have a slight salmon tinge. *Veil* peronate two-thirds up, the loose part or *ring* smooth above with a few floccose squamules below, wide or narrow; large part of veil often adheres to margin of pileus. *Flesh* white turning salmon pink in stem, sometimes only in patches. *Smell* variable, in young stages of anise or almonds, but often most unpleasant when old. *Taste* mild, slightly rancid when raw, but a very good edible. *Spore powder* brownish black. *Spores* elongate pip-shaped 10–12 × 5–6 μ. *Gill edge* sterile with club-shaped cells 8–10 μ wide; sometimes there are globose or ovate cells in clusters, but it is uncertain whether this is merely an adventitious feature of no diagnostic importance.

Habitat: in pastures and especially abundant on chalk soil. Collected in Surrey, Sussex and Hampshire but doubtless present everywhere.

This rather puzzling mushroom, which may vary with weather and soil, is usually determined as *P. arvensis*, from which it differs in the larger spores and coloration, especially the salmon-pink colour of the flesh when exposed to the air.

It is most difficult to come to a conclusion as to its correct name, but we have taken the line of least resistance by adopting the epithet used by Bresadola (*Icon. Myc.* tab. 829) and Lange (*Fl. Ag. Dan.* IV, 56, Pl. 139) though it cannot be assigned with certainty to the original *villatica* of Brondeau in *Mem. Linn. Par.* v, lxvi (1828). However, in view of its variability the Brondeau species may well be the same, for he accentuates the squamulose covering of the stem '*marqué d'écailles très saillantes dans la jeunesse*'.

Miss E. M. Wakefield, who has paid much attention in recent years to

the genus *Psalliota*, associates her name with mine as joint author of the following two species:

Psalliota arenicola n.sp.

Pileus 2–7 cm. wide, fleshy, very compact and firm, semi-globate then flat or slightly depressed in centre, smooth, silky, white, persistently involute, cuticle overlapping the gills and shaggy. *Gills* very crowded, free, at first very pale pink, finally brownish black, ventricose or wedge-shaped, edge white and fimbriate. *Stem* 3–4 cm. long, 1–1·5 cm. thick, cylindrical, equal or slightly swollen at base, solid and hard, white, turning reddish when rubbed, the lower part peronate to middle at first, soon breaking up into ring-like fugacious fragments, smooth and silky when old, a distinct ring not always present and when present very narrow with shaggy edge. Long mycelial threads are sometimes at the base of the stem. *Flesh* white turning brownish red in lower part of stem. *Smell* not distinctive. *Taste* mild. *Spores* in mass, blackish brown; subglobose 5–6 × 4·5 μ, one-guttulate. *Basidia* four-spored. *Gill edge* sterile with sack-shaped cells about 10 μ wide.

Habitat: in sand, often so buried that the top of cap only is showing; in troops. Braunton Burrows, North Devon, November and December 1944, November 1945. Sent by Dr F. R. Elliston Wright.

Type specimens at the Herbarium, Royal Botanic Gardens, Kew, Surrey.

LATIN DIAGNOSIS: *Psalliota arenicola* Wakefield & Pearson. *Pileus 2–7 cm. latus, albidus, carnosus, solidus, e convexo planus vel sub-depressus, glabratus, sericeus, margine semper involuto, cute lacerata ultra lamellas excedente. Lamellae confertissimae, liberae, e pallidis rubescentes, demum nigro-brunneae, ventricosae vel cuneatae, acie alba minute fimbriata. Stipes 3–4 cm. longus, 1–1·5 cm. crassus, cylindraceus, vel basi sub-bulbosus, solidus, firmus, albidus tactu rubescens, deorsum primo peronatus, deinde veli fragmentis annulatis ornatus demum glabratus sericeusque. Annulus angustus, mox evanescens. Caro alba ad basim stipitis rubescens, odore subnullo et sapore grato. Sporae nigro-brunneae late ellipsoideae vel sub-globosae* 5–6 × 4·5 μ. *Basidia tetraspora. Acies lamellarum sterilis cellulis clavatis circa* 10 μ *latis.*

Habitat: in terra arenaria prope mare, saepe in arena sepulta, summo pilei modo visibili.

Psalliota litoralis n.sp.

Pileus 7–8 cm. wide, convex with flat or depressed centre, fleshy, light buff or biscuit colour, becoming darker and finally pale tawny brown or ochraceous tawny (Ridgway), fibrillose at first, breaking up into small or large flat scales, margin incurved exceeding gills and shaggy with appendiculate veil. *Gills* very crowded, free, rather wide, pointed both ends, at first pallid, finally black with slight purplish tinge; edge white, fimbriate. *Stem* 3–4 cm. long, 1·5–2 cm. thick, cylindrical, solid, white, striate above ring, reddish brown below. *Ring* median or two-thirds up, lower part sheathing stem, upper part spreading 8–10 mm. *Flesh* white in pileus, reddish brown in stem. *Smell* faint, not distinctive of mushrooms. *Spore powder* mummy brown (Ridgway). *Spores* elliptical apiculate 6–8 × 4·5–5 μ, one-guttulate. *Gill edge* sterile with long cylindrical cells 5–6 μ wide.

Habitat: in short turf exposed to sea breezes. Saunton Down, North Devon, June 1945. Sent by Dr F. R. Elliston Wright.

Type specimens at Herbarium, Royal Botanic Gardens, Kew, Surrey.

LATIN DIAGNOSIS: *Psalliota litoralis* Wakefield & Pearson. *Pileus 7–8 cm. latus, carnosus, ex hemisphaerico expansus vel depressus, alutaceus, demum obscurior denique fulvo-brunneus, cuticula primo fibrillosa deinde in squamulas vel squamas adnatas diffissa; margo incurvatus ultra lamellas excedens; velum album ad marginem lacerato-appendiculatum. Lamellae confertissimae, liberae c. 5 mm. latae e pallidis purpureo-fuscae, acie albo-fimbriata. Stipes 3–4 cm. longus, 1·5–2 cm. diam. cylindraceus, solidus, supra annulum albus striatusque, subter rufo-brunneolus. Annulus membranaceus 8–10 mm. latus, in stipite medio, infra in vaginam productus. Caro pilei alba, stipitis rufo-brunnea, odore grato. Sporae nigro-brunneae ellipsoideae apiculatae 6–8 × 4·5–5 μ uni-guttulatae. Acies lamellarum sterilis cellulis cylindraceis 5–6 latis.*

Habitat: in caespite ad ventum marinum exposita.

Boletus cramesinus Secr. *Mycographie Suisse* (1833). *B. sanguineus* (With.) Fr. var. *gentilis* Quél. (1883). *B. tenuipes* (Cooke) Massee in *Br. Fung. Fl.* 1, 281 (1892).

Pileus 3–12 cm. viscid, smooth or wrinkled, pinkish (crushed strawberry) speckled with a lighter pink. *Tubes* bright chrome or golden yellow, deeply channelled round stem, decurrent in fine lines down apex of stem. *Pores* angular, medium, concolorous, sometimes rufescent when bruised. *Stem* usually slender, sometimes more robust and ventricose, narrowed to a point at base, yellow above, brownish or rufous below. *Flesh* white with faint flush of pink, and a deeper pink near surface. *Smell* not distinctive. *Taste* mild. *Spore powder* clay colour. *Spores* fusiform 12–13 × 4·5–5 μ. *Cystidia* fusiform bright yellow mostly about 60 × 16 μ (50–70 × 14–20 μ, Konrad & Maublanc).

Habitat: mixed wood at Shillinglee, Sussex, 25 October 1943, and at Ruislip Wood, Middlesex, 1 October 1944. Said by Gilbert to be often found on charcoal heaps.

B. cramesinus has nothing to do with *B. sanguineus* (With.) Fr. which is a doubtful species with flesh that turns blue. F. Kallenbach, in his unfinished monograph of *Boletus*, has a good series of figures under the name *B. auriporus* Peck, but from Peck's description it is far from certain that it is the same; anyway Secretan's epithet has priority. The fungus is also well illustrated in the *Ic. Sel. Fung.* of Konrad & Maublanc, Pl. 413 as *B. sanguineus* var. *gentilis*. Normally it is a small *Boletus*, but in September 1945 a specimen with a pileus 12 cm. wide was sent to the Herbarium, Royal Botanic Gardens, Kew, which differed from the type in the large size and in that the chrome yellow pores turned a blood red when bruised. Type specimens of *B. tenuipes* (Cke) Massee have been examined by Dr Dennis and he found brilliant yellow cystidia present, which is a clear indication that it is the same species as described above.

Boletus scaber is a binomial which represents to most European mycologists the common *Boletus* of birch woods with a grey or blackish pileus, minutely tomentose *sub lente*, a rough stem dotted with small scales

and flesh that remains unchangeable when exposed to the air or only has a very faint flush of pink.

It has, however, been claimed in France, and first, we believe, by the eminent mycologist René Maire, that the true *scaber* of Bulliard as figured on Pl. 132 (1809) is another and less common *Boletus* with flesh that turns black. It has been described and illustrated by F. Kallenbach as *Boletus pseudo-scaber* F. Kall. (1935), an epithet which is not valid, since it was used in 1833 by Secretan for another species.

There has been a lively discussion about the matter and the French point of view has been put forward in various papers in the *Bull. Soc. Myc. Fr.* I adopted the names used by the French authors when I prepared the *List of the Fungi of Epping Forest*, published by the Essex Field Club (1938), but on looking into the matter more closely the reasons put forward do not appear convincing. Bulliard's description and figures are not good, and no decision can be based on them. If a French tradition did exist as to the identity of Bulliard's species, it was kept in the background and came to light for the first time in 1933 when the *Bull. Soc. Myc. Fr.* included in its list of species the unfamiliar name of *Boletus leucophaeus* Pers. to indicate the common birch bolet, the one with the white unchangeable flesh, though in the original diagnosis of *B. leucophaeus* the flesh was described as blackening when exposed to the air, so even this name was inappropriate.

However, what almost amounts to a universal tradition cannot be cast aside in this light manner. All that was required was a new name for a 'new' fungus. The new *Boletus* certainly has some features that make it worthy of this distinction. A study of the literature discloses the fact that it had already been described in the 1924 edition of Michael's *Führer für Pilzfreunde* by R. Schulz as *B. scaber* var. *Carpini*, and when raised to specific rank it is to be hoped that this name will be accepted.

Boletus Carpini (R. Schulz) Pearson. *B. scaber* Bull. var. *Carpini* R. Schulz, *Führ. f. Pilzfr.* (1924). *B. pseudo-scaber* Kall. non Secr. *Die Pilze Mitteleuropas*, I, *Die Röhrlinge*, 117, Pl. 40 (1935). *B. scaber* Maire et alt.

Pileus 4–6 cm. wide semi-globate, glabrous but usually strikingly wrinkled, often only in patches or with smooth centre and wrinkled towards margin, then cracked in a network of rather large meshes, pruinose when quite fresh, light buff, snuff brown, milky coffee or tawny olive (Ridgway). *Tubes* cream, very long in relation to cap and projecting beyond margin of pileus, free. *Pores* cream, dirty brown when rubbed. *Stem* 5–13 cm. long, usually slender but ranging from 10 to 40 mm. thick, deeply sulcate and ribbed, attenuated above, with small dark brown or black scales arranged longitudinally on a greyish white background. *Flesh* white at first, slowly turning first a violaceous pink then a mottled black. *Cuticle* of pileus with globose cells 10–12 μ diam. *Spores* in mass, snuff brown; fusiform apiculate 15–17 × 4·75–5 μ slightly hooked one end near apicle.

Habitat: in deciduous woods and copses, especially under hornbeam (*Carpinus Betulus*) and hazel (*Corylus Avellana*); late summer and early

autumn. Found in Surrey, Sussex and North Devon early September 1943–5.

This species which has only recently been recognized as distinct from *Boletus scaber* is really very different. Once known we are surprised that it should have been missed. It has been confused with *Boletus duriusculus* which always grows under poplars, is more robust and cracks, but the cracks make a finer mesh and the surface of the pileus has a stippled appearance.

The above description of *Boletus Carpini* is from specimens gathered at Hindhead, Surrey. A coloured plate from a drawing made by Dr Dennis appears in the *Naturalist*, April 1946.

I have to thank Dr J. Ramsbottom for helping me to a decision as to which epithet should be applied to this much-discussed species.

How are we to cite the authors for *Boletus scaber*? In the *Systema Mycologicum* (1821) *B. scaber* is a collective species so the usual citation *B. scaber* (Bull.) Fr. has little meaning. Krombholz was, I think, the first to describe fully the species as we know it. It is true he did not mention the birch, but the habitat given is just where the birch tree appears: common on heaths, wood clearings and coppices, never in the depths of the forest. If Quélet (1888) is given as the doubtful authority for *scaber* in the French sense, Krombholz (1836) may be cited for the species with unchangeable flesh. *Boletus scaber* (Bull.) Krombh. will at least be unambiguous, but perhaps *B. scaber* auct. will suffice.

There is a variety of *B. scaber* which should be added to our British list. I have come across it two or three times and doubtless would have found it more often if I had taken the trouble to examine the flesh of every specimen of *B. scaber* met with. It was first pointed out by R. Singer in the Swiss journal *Schw. Zeitschrift für Pilzkunde*, XVI, 137 (1938) who then named it *Krombholzia scabra* var. *chromapes* (Frost) which was not acceptable as Frost's species is very different. In the *Ann. Myc.* XL, 32 (1942), he renamed it var. *coloripes* Sing. and under this name it should be recorded.

Boletus scaber var. *coloripes* Sing. Differs from the type in the flesh being golden or sulphur yellow at base of stem, turning a blood red or a greenish blue. First received from Capt. A. Dunston, Donhead-St-Mary, Wiltshire, 21 October 1941; also collected at Hindhead, Surrey, 23 September 1942.

These colour changes require further observation.

Hydnum (*Dryodon*) *cirrhatum* (Pers.) Fr. Pl. XI.

On 22 September 1943, not far from Goodwood, Sussex, we had the good fortune to find a magnificent specimen of this beautiful rare fungus, growing on a prostrate oak trunk. The series of sessile pilei were loosely and irregularly imbricate and as can be seen in the photograph, are of varying size. Further details are as follows: fleshy, rather fragile convex, flat or undulate, margin incurved at first, pale cream staining yellow when bruised or broken. *Top surface* covered with spines, erect in centre, prostrate towards margin. *Hymenium* with long spines 5–15 mm. long, subulate, cream, rusty pink when rubbed and when old. *Flesh* thick behind, thin at

margin, white, unchangeable. *Smell* pleasant. *Taste* mild. *Basidia* with 2 long sterigmata. *Spores* in mass Cambridge buff (Ridgway), amyloid, subglobose 3–3·5 μ often one-guttulate. *Spines of pileus* with masses of conidia similar to spores. *Cystidia* long filiform cells on hymenium which soon break down and are not visible when old.

Pl. XI is from a photograph by Mr Colin G. Fletcher and is about two-thirds the natural size.

Irpex pachyodon (Pers.) Quél. *Fl. Myc.* 377 (1888). *Sistotrema pachyodon* (Pers.) Fr.

Pileus 3–14 cm. wide, sessile, imbricate with 1–5 cm. thick shallow ridges 1–2 cm. apart; surface even, pubescent, white then cream (light buff of Ridgway). *Hymenium* of stalactite spines and plates, pointed or dentate, of varying lengths and widths, colour of pileus. *Flesh* white, soft at first then coriaceous. *Spores* in mass, pale buff; subglobose with 1 large guttule 5–6 μ in our specimens (5–8 × 4·5–6·5 μ, Bourdot & Galzin). *Cystidia* none. *Hyphae* 2–4 μ diam. usually without clamp connections; a few may be present, sec Bourdot & Galzin.

Habitat: on bark of living holm oak. Near East Dean, Sussex, September–November 1943–5.

Pl. XII is from a photograph kindly taken by Mr F. Ballard.

Clavaria versatilis Quél. *Ass. Fr.* (1893).

Receptacle 6–12 cm. high, violaceous drab, then brownish drab with darker tips, finally powdery with the pale ochraceous spores; trunk naked, hollow, white at base, violet above and drab at top, divided into thick cylindrical or compressed branches which are not closely compact but rather loose and not pressed against each other; more or less dichotomously divided into numerous branchlets with toothed apices which may be violet when fresh but are usually ferruginous brown. *Flesh* white unchangeable, inodorous. *Basidia* long and narrow 30–40 × 6–8 μ. *Spore powder* pale ochre (chamois of Ridgway). *Spores* oblong apiculate (sub-fusiform) with granular contents 8–9 × 4·5–5 μ minutely aculeate. *Hyphae* not clearly defined, of various diameters.

Habitat: on bank under beech trees. Henley Hill, Sussex, September and October 1942–3. Quélet's epithet has been used, but *C. fennica* Karst. would have priority if it is the same species. It is certainly very close, but its habitat is in coniferous wood. *C. versatilis* is said to be not uncommon in the beech woods of France.

Clavaria botrytis (Pers.) Fr. var. **alba** n.v.

All parts pure white except the spores which are the normal colour, pallid ochre (chamois of Ridgway). Several tufts were growing on a bank under beeches at Henley, Sussex, October 1942.

(*Differt a typo colore omnino albo*; *sporis dilute ochraceis ut in typo.*)

EXPLANATION OF PLATES IX–XII

Plate IX

Fig. A. *Stropharia rugoso-annulata* Farlow.
Fig. B. *Cortinarius ammophilus* Pearson.
Fig. C. *Inocybe griseo-lilacina* Lange.
Fig. D. *Mycena arcangeliana* Bres. var. *Oortiana* Kühner.

Plate X

Stropharia rugoso-annulata Farlow.

Plate XI

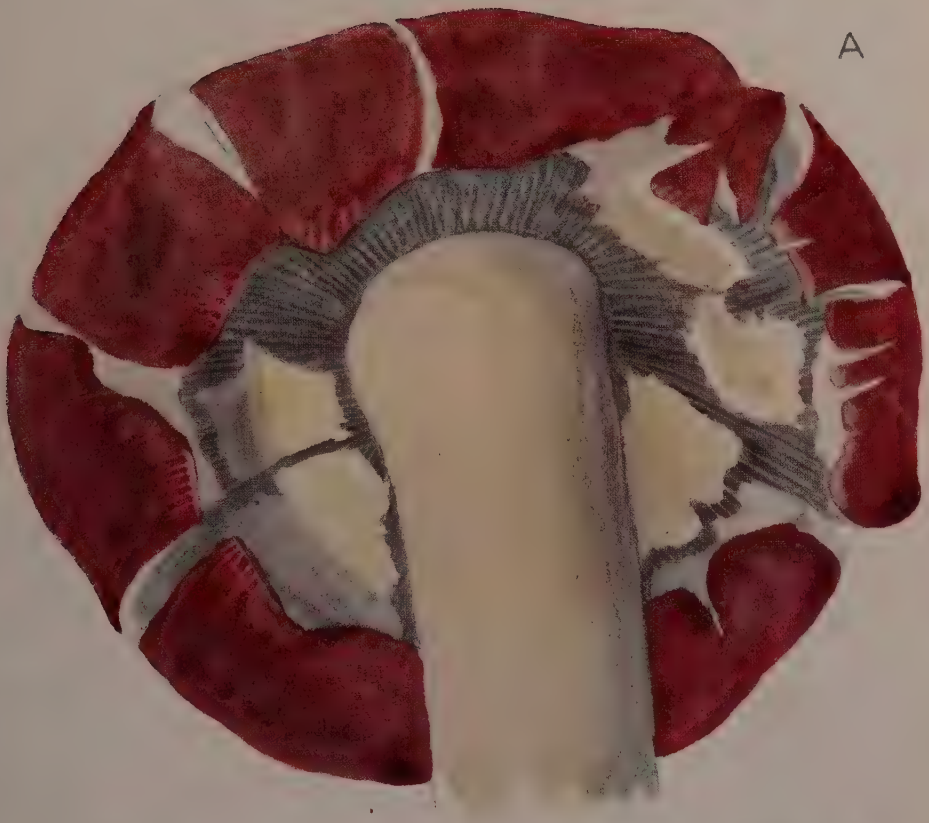
Hydnum cirrhatum (Pers.) Fr.

Plate XII

Irpex pachyodon (Pers.) Quél.

(*Accepted for publication* 18 *March* 1946)

A
B
B
A


A

C
D

A

B

C

PRODUCTION OF GLIOTOXIN BY *PENICILLIUM TERLIKOWSKII* ZAL.

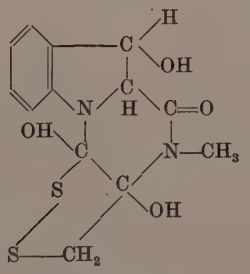
By P. W. BRIAN, *Hawthorndale Laboratories, Jealott's Hill Research Station*

Gliotoxin was one of the first antibiotic substances to be isolated in pure form (Weindling & Emerson, 1936) and has since been found to be a metabolic product of a variety of moulds. A list of those fungi which have been said to produce gliotoxin is given below:

Aspergillus fumigatus Fres. (Menzel, Wintersteiner & Hoogerheide, 1944).
Aspergillus fumigatus mut. *helvola* Yuill (Glister & Williams, 1944).
Penicillium Jenseni Zal. (Brian, Hemming & McGowan, 1945).
Penicillium obscurum Biourge (Mull, Townby & Scholz, 1945).
Penicillium sp. (unidentified) (Johnson, McCrone & Bruce, 1944).
Trichoderma viride Pers. ex Fries (Weindling & Emerson, 1936; Brian, 1944).

Whether gliotoxin is produced by *Gliocladium fimbriatum* Gilman & Abbott or not, is open to some doubt; it seems probable that the organism used under that name by Weindling (1937) was, in fact, a strain of *Trichoderma viride* (Brian, 1944). The organism described above as *Penicillium Jenseni* is now identified as *P. Terlikowskii* Zal.

The chemistry of gliotoxin has been intensively investigated (Johnson, Bruce & Dutcher, 1943; Johnson *et al.* 1944; Bruce, Dutcher, Johnson & Miller, 1944; Dutcher, Johnson & Bruce, 1944; Johnson, Hasbrouck, Dutcher & Bruce, 1945; Dutcher, Johnson & Bruce, 1945), the most probable structural formula for gliotoxin, in the opinion of these workers, being



The biological properties of gliotoxin have also been widely studied. It is actively antibacterial (Waksman & Woodruff, 1942; Johnson *et al.* 1943; Rake, Jones & McKee, 1943; Schatz & Waksman, 1944; Brian & Hemming, 1945), Gram-positive and Gram-negative bacteria being equally sensitive; of interest is the recent discovery of its great *in vitro* toxicity to *Mycobacterium tuberculosis* (Schatz & Waksman, 1944). It is highly fungistatic; saprophytic and plant pathogenic fungi are sensitive (Weindling,

1941; Waksman & Bugie, 1943; Brian & Hemming, 1945; Brian *et al.* 1945; Reilly, Schatz & Waksman, 1945) and also a number of dermatophytic fungi (Reilly *et al.* 1945; Sanders, 1946). Gliotoxin is toxic to mammals (Johnson *et al.* 1943).

In view of the considerable amount of information available concerning gliotoxin, this communication is confined to a brief description of the conditions under which it is produced by *Penicillium Terlikowskii* with a discussion of its natural importance.

Source and characteristics of *Penicillium Terlikowskii*

The strains of *P. Terlikowskii* used in this study were isolated from Wareham Heath soil and were originally identified as *P. Jenseni* (Brian *et al.* 1945). Wareham Heath soil is directly or indirectly toxic to coniferous trees (Rayner, 1934). This toxicity, associated with a general low level of microbiological activity, was shown to be of biological origin by Neilson Jones (1941); it has since been suggested (Brian *et al.* 1945) that production of gliotoxin by the organism now identified as *P. Terlikowskii*, which is very abundant in this soil, may be one factor involved.

Colonies of our isolates on Czapek-Dox agar are closely felted, almost velvety. The colony showed no folding and the centre is only slightly raised; the margin is white, 3–4 mm. in width. Conidial areas are sage green and the reverse initially white, slowly developing traces of pink. Colourless transpiration drops are formed, some becoming yellowish or reddish in the older parts of the colony. There is no odour. The penicilli are monoverticillate, borne on short branches from a fertile hypha. The sterigmata are 8·5–10μ in length, bearing conidial chains in compact columns. The conidia are smooth and globose, 2·5μ in diameter.

This is fairly close to the description of *P. Jenseni* Zal. given by Thom (1930), the main points of difference being the absence of any complex penicilli and the absence of obvious connectives on the conidia. Two strains (241 and 244) were submitted to Dr K. B. Raper (United States Department of Agriculture) who has kindly commented as follows: 'Your strains 241 and 244 are tentatively identified as *P. Terlikowskii* Zaleski. These strains are monoverticillate and do not agree with Zaleski's figures which place *P. Jenseni* in the Lanata-Divaricata of Thom. If we interpret the strains as belonging in the Monoverticillata-Ramigena, your strains do key to *P. Jenseni*. If they are interpreted as Stricta-Funiculosa with ropiness reduced, the strains key to *P. Terlikowskii* and agree with the species description fairly well except conidiophores appear smooth and not rough, as described by Thom.'

As these strains do appear to agree more closely with *P. Terlikowskii* than with *P. Jenseni*, although there is still an element of doubt in the diagnosis, they are referred to throughout this paper under the former name.

This mould shows the dual phenomenon described by Hansen (1938) very strongly. Cultures made by mass conidial transfer exhibit a continuous tendency to produce white mycelial overgrowths, which swamp the conidial areas. Transfers of this mycelium remain sterile. It is shown

later in this paper that the mycelial form is much less antibiotically active than the conidial form.

Experimental methods

In all the experiments described here the procedure has been to set up replicate cultures on 30 ml. lots of medium in 100 ml. Pyrex flasks, five such cultures being withdrawn at random and bulked for assay of fungistatic activity at appropriate intervals. The composition of the Weindling, Raulin-Thom and Czapek-Dox media has been previously given (Brian, Curtis & Hemming, 1946). All cultures were incubated at 25° C.

Assays of fungistatic activity have been carried out by a serial dilution spore germination test, using conidia of *Botrytis Allii* Munn. The method has been described in detail by Brian and Hemming (1945).

Table 1. *Development of fungistatic activity (in* B.A. *units/ml.) in cultures of* Penicillium Terlikowskii *on four standard media*

Strain no.	Days incubation	Medium			
		Weindling	Czapek-Dox	Raulin-Thom	Cornsteep
241	6	32	16	12	16
	8	96	24	64	24
	10	48	24	48	16
	12	64	24	32	8
245	6	8	8	16	16
	8	8	8	16	32
	10	12	8	8	12
	12	8	8	8	8
244	6	2	—	8	4
	8	—	—	4	4
	10	—	2	12	—
	12	2	4	8	2

Relation of composition of medium to development of fungistatic activity

Comparison of standard media

Table 1 shows the development of fungistatic activity in culture filtrates from three strains of *P. Jenseni* growing on four standard media. It will be seen that of the three strains no. 241 is the best; all experiments subsequently described refer to this isolate or various substrains derived from it. Of the four media, Weindling and Raulin-Thom were best, though the superiority of these two media over Czapek-Dox or Cornsteep was not so marked as is the case with gliotoxin production by *Trichoderma viride* (Brian & Hemming, 1945).

Variation of carbon source in Weindling medium

Using isolate no. 241 on a Weindling medium with various pure carbon sources, it was found that maltose, lactose, galactose and dextrin were most suitable for development of fungistatic activity, followed closely by starch, dextrose and sucrose; no activity developed in media containing carbon as ethyl alcohol, glycerol, mannitol, citrate or tartrate.

Concentrations of dextrose from 1 to 5 % have been tested. Increase from 1 to 2 % increases the final activity, but further increase in dextrose concentration was not of advantage.

Variation of nitrogen source in Weindling medium

In similar experiments to those just described it was found that sodium nitrate, ammonium tartrate, ammonium sulphate, ammonium nitrate and peptone were equally suitable nitrogen sources.

Initial pH of Weindling medium

Weindling medium was adjusted to various *p*H values, ranging from 2·3 to 6·0, with hydrochloric acid or sodium hydroxide. The development of fungistatic activity and the drift of *p*H in culture filtrates, after growth of *Penicillium Terlikowskii*, are shown in Table 2.

Table 2. *Development of fungistatic activity* (B.A. *units/ml.*) *in cultures of* Penicillium Terlikowskii *on Weindling medium adjusted to various initial p*H *values*

Initial *p*H of medium	Fungistatic activity				*p*H			
	6	8	10	12 days	6	8	10	12 days
2·3	8	8	8	8	1·9	1·2	2·1	2·0
3·0	16	8	8	8	2·2	2·2	2·5	2·2
4·4	32	32	48	48	2·9	2·8	3·2	2·9
5·2	32	48	48	32	3·1	2·9	3·4	3·1
6·0	32	64	48	48	3·1	3·1	3·8	3·6

Growth was good on all the media, but sporulation was poor on the two with lowest initial *p*H (2·3 and 3·0). The media with high initial *p*H were best for development of fungistatic activity. It is well established that gliotoxin rapidly decomposes at reactions of *p*H 4·0 or higher, and it is therefore of interest to note that the *p*H of all media rapidly fell to *p*H 3·1 or less.

Accessory factors

In the experiments detailed in Tables 1 and 2 an impure form of dextrose (crude glucose chips) was used in the media. In the course of other experiments it was noted that this crude glucose was much superior, both for growth of *P. Terlikowskii* and for development of fungistatic activity, to pure dextrose. Spectrographic examination of the two samples showed the impure form to be higher in iron, manganese and zinc. The effect of addition of minor elements to media containing pure dextrose or crude glucose was therefore examined. Minor elements were added at two levels, the lower level being based on the minimal requirements for *Aspergillus niger* as determined by Steinberg (1935). The minor elements added were:

Element	Concentration (μg./ml.)	
	Low level	High level
Fe	0·2	1·0
Cu	0·03	0·15
Zn	0·2	1·0
Mn	0·02	0·1
Mo	0·02	0·1

The results of such an experiment are shown in Table 3. It is clear that addition of the minor elements did not bring the pure dextrose media up to the level of those containing crude glucose though sporulation was slightly improved.

Similarly, it was found that addition of calcium salts, also present in the crude glucose, did not increase fungistatic activity in pure dextrose media though again sporulation was slightly improved.

Table 3. *Effect of minor elements on development of fungistatic activity* (B.A. *units/ml.*) *in cultures of* Penicillium Terlikowskii *on Weindling media containing pure dextrose or crude glucose*

Grade of dextrose	Days growth	Minor element level		
		None	Low	High
Pure	6	4	—	2
	8	4	—	4
	10	8	2	—
Crude	6	12	12	12
	8	24	64	16
	10	32	32	24

Organic supplements such as peptone, yeast extract, aneurin hydrochloride, nicotinic acid, riboflavin, inositol, β-indolyl acetic acid or pyridoxin similarly had no effect on the development of fungistatic activity. The nature of the stimulatory material in crude glucose therefore remains unknown.

Strain variation

It has been mentioned earlier that *P. Terlikowskii* shows a tendency to produce a sterile white mycelial form which outgrows the conidial form. In a number of experiments very low fungistatic activity of culture filtrates was associated with predominance of the mycelial form. From strain no. 241 it was found possible by single-spore cultures to isolate sterile mycelial forms, intermediate forms showing sparse sporulation and conidial forms sporulating more or less vigorously. These latter single-spore cultures still showed the tendency to produce the sterile mycelial form in subcultures. Several of these single-spore strains were compared on Weindling medium for production of fungistatic activity; results are shown in Table 4. These results show quite clearly that the purely mycelial forms are valueless for gliotoxin production, the conidial forms being outstandingly superior.

The natural significance of gliotoxin production

Gliotoxin has been shown to be produced by *Aspergillus fumigatus*, *Trichoderma viride*, *Penicillium obscurum* and *P. Terlikowskii*, and in all probability will be found to be produced by yet more mould species. Of these, *Trichoderma viride* and *Aspergillus fumigatus* are widespread and abundant in soil, *Trichoderma viride* in all parts of the world, *Aspergillus fumigatus* more particularly in the warmer regions. *Penicillium Terlikowskii* has been shown to be abundant, at least in certain soils, in England, and was first recorded by Zaleski (1927) from a pine-forest soil in Poland.

Consideration of other antibiotic substances confirms the existence of a strong correlation between production of antibiotic substances by micro-organisms and the soil habitat. The mould antibiotics penicillin and claviformin (also known as clavacin and patulin) are each known to be produced by several distinct fungi, in the main characteristically found in soil. The actinomycete antibiotics streptomycin, streptothricin, actinomycin, actinomycetin, proactinomycin and others are produced by soil actinomycetes. Most of the bacteria known to produce antibiotic substances are typical soil organisms.

Most antibiotic substances of microbial origin, then, are characteristically produced by soil organisms, and, in the present state of our knowledge of the distribution of the organisms concerned, it would appear that those producing gliotoxin are particularly widespread.

Table 4. *Comparison of single-spore strains of* Penicillium Terlikowskii *for production of fungistatic culture filtrates*

Strain no.	Type	Activity (B.A. units/ml.) 6	8	10 days
241/1	Mycelial	—	—	—
241/2	Mycelial	6	4	4
241/3	Intermediate	12	12	6
241/4	Conidial	128	64	32
241/5	Conidial	64	48	32
241/6	Conidial	64	32	24
241/7	Conidial	128	64	64

The role of antibiotics in nature has not yet received the study which the subject deserves. It is easy to appreciate that, in a closed environment such as the soil, the secretion into the surrounding medium of a substance toxic to other organisms utilizing similar nutrients may be of considerable competitive value, and hence of evolutionary significance, to the organism producing the antibiotic. On the other hand, if this were the case one would expect that antibiotic-producing strains of soil fungi would be favoured by natural selection and would become the dominant strains. Experience has shown that, on the contrary, strains producing high yields of antibiotics are relatively uncommon, and strains of the same species producing none at all are quite common. These facts illustrate the need for biological studies in relation to antibiotic-producing soil micro-organisms. It would be of interest to study, for instance, the survival of conidial gliotoxin-producing strains of *P. Terlikowskii* and the mycelial strains of low antibiotic activity; in pure culture the mycelial strains are most vigorous, but in soil the situation might be very different. The distribution of viridin-producing, gliotoxin-producing and antibiotically inactive strains of *Trichoderma viride* also seems worthy of investigation, and similarly with strains of other micro-organisms producing antibiotic substances.

The production of antibiotics probably profoundly affects the maintenance of microbiological equilibria in the soil. The toxicity of Wareham Heath soil to certain mycorrhizal fungi has been attributed by Brian *et al.* (1945) to accumulation of gliotoxin. Support for this view has been

obtained by correlation of the sensitivity to gliotoxin of various mycorrhizal and other soil fungi with their observed abundance and distribution on Wareham Heath (Rayner, 1945). Newman and Norman (1943) have suggested that the low level of microbiological activity in subsurface soils is due to leaching down of antibiotic substances produced by micro-organisms in the surface soil. It seems reasonable to suppose that many other aspects of microbiological balance, such as the phenomenon of soil sickness and its cure by partial sterilization, which may have a considerable effect on soil fertility, are at least in part concerned with the production of antibiotic substances by soil micro-organisms. In the more acid soils, where it would be relatively stable, gliotoxin is probably of great importance in this connexion.

Summary

A *Penicillium* producing gliotoxin, isolated from Wareham Heath soil, has been identified as *P. Terlikowskii* Zal.

Culture filtrates from this mould developed greater fungistatic activity on Raulin-Thom and Weindling media than on Czapek-Dox or a Corn-steep medium. In Weindling, a wide variety of carbon sources may be used and ammonium, peptone and nitrate nitrogen is suitable as a nitrogen source. The initial *p*H of the medium should be above *p*H 4·0.

An impurity in a crude grade of glucose used in some of the culture media was found to increase sporulation and to stimulate greatly development of fungistatic activity in culture filtrates. It has not been found possible to associate this effect with various minor elements (iron, copper, zinc, manganese, molybdenum), calcium, various vitamins (aneurin, nicotinic acid, riboflavin, inositol, pyridoxin, β-indolyl acetic acid), peptone or yeast extract.

There is considerable variation in the capacity to produce gliotoxin among strains of *P. Terlikowskii*; a common sterile mycelial variant, though vigorous in growth, produces little, if any, gliotoxin.

The possible significance of gliotoxin as a factor concerned in the maintenance of microbiological equilibria in soil is discussed.

I am indebted to Miss Myrtle Bray and Mr H. G. Hemming for much technical assistance during the course of this investigation.

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THE OCCURRENCE OF PERITHECIA OF THE OAK MILDEW IN BRITAIN

By NOEL ROBERTSON and IAN MACFARLANE

During a foray to Bricketwood, Hertfordshire, on 6 October 1945, six perithecia (cleistocarps) of the Oak Mildew were found on a living leaf of *Quercus Robur* L. Many living leaves bearing the mildew were examined, some from the same tree and some from other trees nearby, but no more perithecia were found. This collection, like those of other powdery mildews hitherto found on oaks, proved to belong to the genus *Microsphaera*, which is distinguished from the other genera of Erysiphaceae by the presence of more than one ascus in the perithecium and by the characteristic dichotomous branching of the tips of the appendages. The mycelium was abundantly developed, mainly on the adaxial surface of the leaf, and bore elliptical to barrel-shaped conidia measuring 25–37 × 15–22 μ with an average size of 31 × 19 μ. The perithecia were 180–200 μ in diameter, the appendages, twenty to twenty-four in number, were from 170 to 300 μ in length and the spores (twenty from three perithecia) measured 18–24 × 6–13 μ.

The perithecia of the Oak Mildew have been recorded from many European countries at infrequent intervals (Blumer, 1933), the earliest record being that of Arnaud and Foëx (1912) from south-west France in 1911. The perithecia have only recently been recorded from those countries with a maritime climate: they were found in Norway in 1932 (Jørstad, 1945) and in Holland in 1939 (Hartsuijker, 1939), and have still to be recorded from Sweden and Belgium. It is generally believed that the development of the perithecia is inhibited in a maritime climate, whereas their development is encouraged by periods of hot, dry weather. Laibach (1930), using potted plants, has shown that by keeping the soil dry, or by reducing the relative humidity of the surrounding atmosphere (or by combining both treatments) he was able to induce the production of perithecia. Conditions at Bricketwood seemed dry for the time of the year, and the number of terricolous Hymenomycetes was abnormally low according to those who had visited the wood in previous autumns. Weather records collected at Rothamsted (eight miles away) showed that the total rainfall in the thirty-three days from 4 September to 6 October 1945, was about half (1·113 in.) that of the average for the same period in the ten previous years (2·25 in.), but, in the absence of extensive data on the subject, we do not wish to imply any causal relationship between the dryness of the season and the occurrence of the perithecia.

We have identified the fungus provisionally with *Microsphaera alphitoides* Griff. & Maubl. (1912), since it agrees closely with the description of the original authors and also with that of Blumer (1933). We have matched our specimen with the exsiccatus no. 3099 of Sydow's *Mycotheca Germanica*, issued as *M. alphitoides*, and find that it agrees closely. The average diameter of the perithecia collected at Bricketwood is 180 μ compared with Blumer's

report of 116μ (range 103–130μ), but the other characters agree, and we think that we are dealing with the same fungus. If this variation in different collections is caused by environmental conditions, it is possible that the perithecial diameter should not have the importance given it by Blumer in his delimitation of species. We have seen one collection of *M. densissima* (Schw.) Cooke & Peck (collection by Gerard from the vicinity of New York, in Herb. M. C. Cooke, 1885 in the herbarium of the Royal Botanic Garden, Edinburgh), from which it is difficult to differentiate *M. alphitoides* on morphological grounds alone, although the distal dichotomy of the appendages in *M. densissima* appears to be more elaborate. This last character is a variable one, however, and we have observed some perithecia in which the appendages were very similar to those of *M. alphitoides* (our own specimen and Sydow's no. 3099). It may be worth noting that the type collection of *M. alphitoides* Griff. & Maubl. is the perithecial material collected by Arnaud and Foex and identified by them with the American species *M. quercina* (Schw.) Burr. Further study of the variation of the American Oak Mildews may show that the European form could be included as one variant within a complex. Since the first discovery of its perithecia in 1911 the descriptions and collections of the Oak Mildew in Europe have been consistent, the fungus is distinctive among the oak mildews in the massive development of a thick, white mycelium and, as far as is known (see Neger, 1915), it is more or less confined to the European oaks, with records on the beech (*Fagus sylvatica* L.) and the chestnut (*Castanea sativa* Mill.). This combination of uniformity with host range and geographical distribution suggests that it is useful to maintain *Microsphaera alphitoides* as the name of the European Oak Mildew, until further investigation of the variability and host range of the American oak mildews, which have been classified differently by almost everyone who has studied them, finally settles the question of its identity.

Permanent mounts of single perithecia have been made and deposited in the British Museum (Natural History), the Herbarium of the Royal Botanic Gardens, Kew, the Herbarium of the Royal Botanic Garden, Edinburgh and in the Cambridge Botany School.

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OBSERVATIONS ON WILT DISEASE OF FLAX

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(With Plate XIII and 2 Text-figures)

In 1942 an investigation was begun on the effects of certain seed treatments on the prevention of seed-borne diseases in oil varieties of flax. The fungicides used during the first year's trials were Nomersan and Agrosan G, applied dry in the form of a fine powder at the rate of 0·6 %, and the flax varieties tried were La Plata (a collection of regional strains from the Argentine) and Bison and Redwing (consisting of uniform, carefully selected seed from Canada).

The distribution of pathogenic fungi on the untreated seed was determined by the Ulster method of Muskett and Malone (1941) and is shown in Table 1. The percentage of seed infected with any one of these diseases was 1 % or less.

Table 1. *Distribution of pathogenic fungi on flax seed*

Flax variety	Pathogenic fungi
La Plata	*Botrytis cinerea* Fr.
Bison	*Colletotrichum linicola* Pethybr. & Laff.
Redwing	*Botrytis cinerea* Fr.
	Fusarium Lini Bolley = *F. oxysporum* Fr. f. *Lini* (Bolley)
	Fusarium culmorum (W. G. Sm.) Sacc.
	Polyspora Lini Laff.

The treated and untreated seeds were sown in randomized, replicated rows eight inches apart at a rate equivalent to fifty pounds per acre. The date of sowing was 20 May 1942, exceptionally late for flax.

The prolonged drought of April and May had broken with slight rain two days before sowing commenced, but the soil was still warm at the time of planting. The weather continued showery with bright intervals for the next fortnight. Mainly warm, dry weather followed for the rest of June. July, on the whole, was cool, dull and showery, but improved towards the end of the month when the plants were in flower or beginning to fruit. The ripening period during August was warm and damp.

Of the fungi carried on the seed which were potential sources of disease, two caused serious trouble in the field. *Polyspora Lini*, inconspicuous at the seedling and stem-break stages, became epidemic during the later browning phase when the warm, damp weather of August favoured its development. *Fusarium Lini* was even more important, especially during the early stages in the growth of the crop.

Before the end of the third week after sowing it was noticed that many seedlings were dying. The cotyledons were not marked by any lesions, but became dull and limp and the edges rolled up. At ground-level the base of the hypocotyl or the top of the radicle had a thin, constricted appearance. The diseased seedlings drooped over on to the ground and died. In hot,

sunny weather the dead seedlings dried up into fine, dry, brittle threads, but on still, warm, humid days they became covered with a white mycelium which could also be seen on small lumps of soil carried up on the testa, and even growing on the cotyledons and on the top of the hypocotyl of living seedlings. When brought indoors and incubated in a damp atmosphere at 25° C., the diseased seedlings invariably became covered with a mycelium which soon produced micro- and macroconidia and later chlamydospores subsequently identified as those of *F. Lini* (Wilson, 1944). The symptoms of this seedling disease agree with those of wilt disease caused by *F. Lini* described by Bolley (1901 *a*) and Millikan (1945), and, less fully, by several other authors.

Seedlings of all varieties were affected to some extent, but particularly those of Redwing, the original source of the infection, and of La Plata. At later stages La Plata was so much more susceptible that the rows of this variety could be picked out from the rest by the large number of dying

Table 2. *Mortality due to wilt disease in* 1942 *crop*

Variety	Treatment	Seeds per ft. at 50 lb. per acre	Seedlings per ft.		Mature plants per ft.
			Alive	Dead	
La Plata	None	45	20	6	9
	0·6 % Nomersan	45	24	4	8
	0·6 % Agrosan G	45	20	10	8
Bison	None	58	34	4	22
	0·6 % Nomersan	58	39	1	28
	0·6 % Agrosan G	58	31	5	19
Redwing	None	68	35	8	21
	0·6 % Nomersan	68	40	10	29
	0·6 % Agrosan G	68	39	9	25

plants which they contained (Table 2). La Plata is known to be very susceptible to wilt. Redwing is generally regarded in North America & resistant and Bison as very resistant (Dillman, 1928, 1936; Allison as Christensen, 1938; Borlaug & Christensen, 1941; Schuster, 1944), but these two varieties, especially Redwing, are more susceptible to the strains of *F. Lini* in New Zealand and Australia (Bayliss, 1940; Millikan, 1945).

When older plants were attacked, the cotyledons and lower leaves of the plant wilted, turning yellow from the edge inwards and then becoming brown and withered and later falling off. The top of the plant sometimes drooped over to one side. Finally, the infection spread until the whole plant was withered and dead. Unlike the wilted seedlings, the dead plant remained erect. The base of the stem at soil level which at first was thin and wrinkled, owing to the partial destruction of the cortex, later became much thickened, a feature of the disease to which attention was drawn by Barker (1923). The roots were less noticeably affected than the shoots, but sometimes showed decorticated areas.

It will be noticed from Table 2 that the rate of spread of the fungus within the first twenty days was extremely rapid. Edwards (1945) has found that the diameter of the mycelium of the fungus on 2 % malt agar adjusted

to *p*H 7·5 and kept at 23° C. (optimum conditions) is only 50–52 mm. after five days. It therefore seems impossible that the fungus could have grown through the soil from the infected seed of Redwing to attack plants in other rows eight inches away, in twenty days. Bolley (1901 *a*, *b*) states that conidia, which are formed in great numbers on the surface of the soil, may be carried long distances in surface drainage waters, and that small quantities of infected soil or pieces of sick plants blown by the wind or carried on the feet or on agricultural implements may be enough to start the disease in clean soil, but he does not consider that the wind dispersal of conidia occurs to any marked extent. It has been observed, however, that when steam-sterilized soil is artificially infected with a culture of *F. Lini* and kept at 23–24° C. in a humid atmosphere, microconidia are produced on the surface of the soil within twenty-four hours of inoculation and macroconidia appear soon afterwards. Uninoculated pots of steam-sterilized soil, placed at a distance of three feet from infected pots, invariably become diseased under these conditions, and this can only be due to the air dispersal of the conidia. Such warm, humid conditions are rarely found out of doors, but did occur during the early stages of germination in 1942 when the surface growth of the fungus on the soil and on dead seedlings was observed. No evidence of long-distance transmission of conidia was found.

Of those plants which survived in the 1942 crop, many of all varieties were conspicuously stunted. The stunted plants were more common in the varieties Bison and Redwing than in La Plata. Some were only a few inches high, many did not flower at all and others produced only a single capsule. Among the dwarfed plants and also in rows where large sections had been completely wiped out, there stood up a few conspicuously well-grown plants which had either enjoyed complete immunity or which the infection had not reached. Most of the few remaining plants of La Plata fell into this category.

Isolations of *F. Lini* were made, not only from the original seed of Redwing, but also, after surface sterilization, from seedlings, from the stem and root of older wilting plants, from stunted plants of all varieties and from the seed produced by the crop. These isolates were used to infect pots of steam-sterilized soil in which healthy seed of La Plata was sown. When kept at a temperature of 23–24° C. all the plants developed the symptoms of wilt disease noted in the experimental plots, and died within periods varying between twenty to thirty-seven days. It was possible to re-isolate the fungus from the dead seedlings. The fungus thus proved even more virulent under these conditions than in the field.

The distribution of diseases on the seed gathered from the 1942 crop was determined by the Ulster method and is shown in Table 3.

The seed produced from the untreated Redwing was the most heavily infected with *Polyspora Lini*, and was therefore selected for testing the efficacy of Nomersan and Agrosan G in controlling this fungus when the seeds were tested by the Ulster method. It was found in one test using 400 seeds that Nomersan reduced the infection of *P. Lini* from 55 to 2 %, while Agrosan G suppressed it altogether. For testing these fungicides against *Fusarium Lini*, seed from Bison was used as, although this was the most

resistant of the three varieties, its seed was the most heavily contaminated. Using the same method as before, it was found that the infection was reduced from 14 to 3 % with Nomersan and to 1 % with Agrosan G.

In 1943 an attempt was made to infect the soil in one bed in which *F. Lini* had been noted in the previous season more thoroughly with this fungus, and for this purpose infected seed from the 1942 crop was sown. This seed also carried *Polyspora Lini*. As might have been expected, the crop was a poor one and disease caused by both fungi was prevalent.

By 1944 the patches of soil infected with *Fusarium Lini* were fairly evenly distributed over the plot, and an attempt was made to find out whether the fungicides which had given a considerable measure of control in laboratory tests were equally effective in the field. Seed of La Plata (the

Table 3. *Distribution of seed-borne diseases on* 1942 *crop*

Variety	Treatment of seed before sowing	% of seed of crop infected with *P. Lini*	*B. cinerea*	*F. Lini*
La Plata	None	21	0	1
	0·6 % Nomersan	9	1	4
	0·6 % Agrosan G	12	0	0
Bison	None	21	3	14
	0·6 % Nomersan	19	3	2
	0·6 % Agrosan G	6	3	3
Redwing	None	55	0	0
	0·6 % Nomersan	38	0	0
	0·6 % Agrosan G	38	0	0

most susceptible variety to wilt available), which was free from all seed-borne diseases except about 0·5 % of *Polyspora Lini*, was chosen. Some was treated with 0·6 % Nomersan, some with 0·6 % Agrosan G and some was left untreated. With these, three kinds of plots were sown in the infected soil on 7 May 1944. Each type of plot was triplicated.

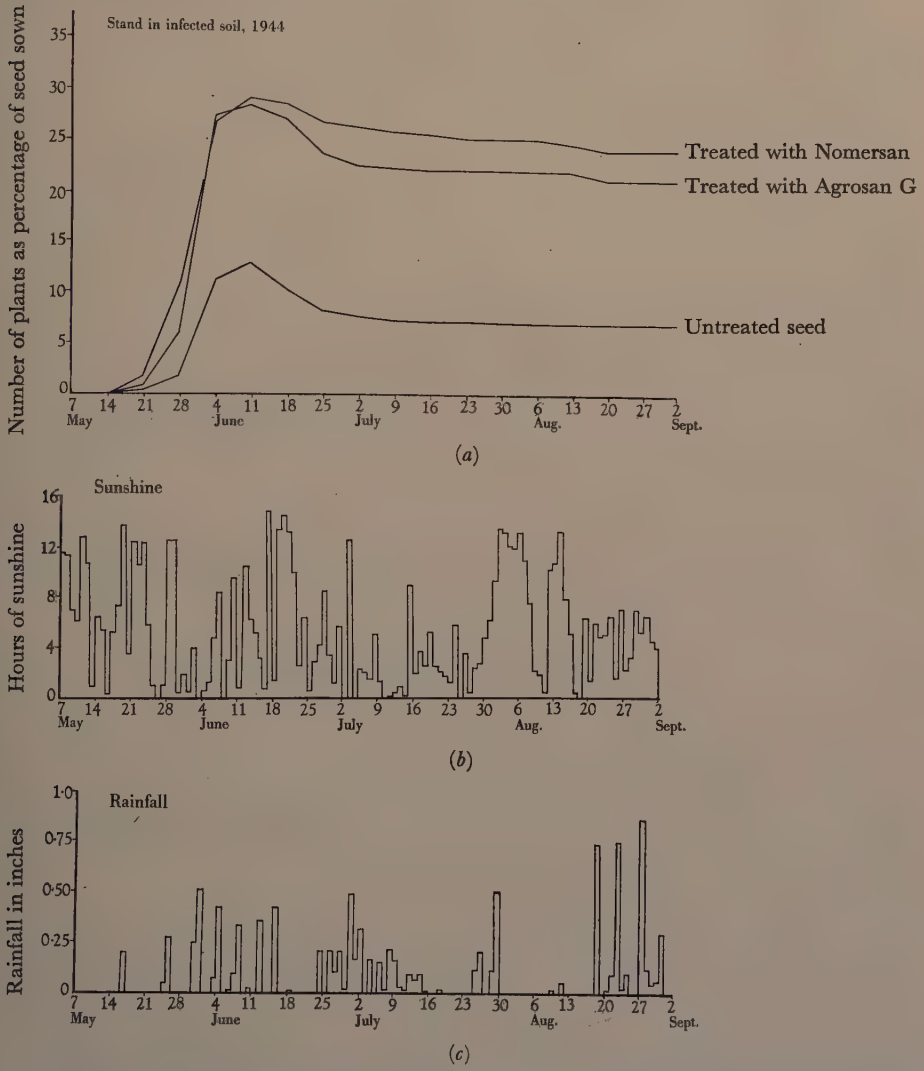
There was some disease caused by *P. Lini*, but this was not conspicuous until the browning phase when the crop was ripening. Wilt, due to *Fusarium Lini*, was more serious and caused severe damage to the crop.

Curves showing the number of surviving plants counted at weekly intervals are shown in Text-fig. 1. There was very heavy mortality at the pre-emergence and early seedling stage of development, germination being only about 30 % in the plots sown with treated seed and only 13 % with untreated seed as compared with a germination rate of 95 % in a neighbouring bed containing similar soil free from *F. Lini*.

The difference between a germination rate of 95 % in one plot and 13 % in another plot of similar soil when both were sown with untreated seed may be ascribed primarily to the presence of *F. Lini* in the latter, but some allowance should be made for the fact that one bed was carrying a flax crop for the third successive year, whereas the other had not been sown with flax before.

The fungicides afforded a striking degree of protection during germination, and this lead over the untreated seed was maintained throughout

development. Analysis of the yields of the crops grown from treated and untreated seed showed that there was no significant difference in the number of flowering shoots on each plant, the number of capsules on each flowering shoot, or the number of seeds in the capsules, the higher yield from the treated seed being due entirely to the greater stand, (Pl. XIII. fig. 1).



Text-fig. 1. (*a*) Graph to show the relative stand of treated and untreated seed of the flax variety La Plata in wilt-infected soil in 1944. (*b*) Sunshine in hours during period of growth of 1944 crop. (*c*) Rainfall in inches during period of growth of 1944 crop.

Text-fig. 1 also shows the daily records for sunshine and rainfall while the crop was growing in 1944. A high mortality rate from wilt disease coincided with periods of dry, sunny weather. Greatest destruction occurred

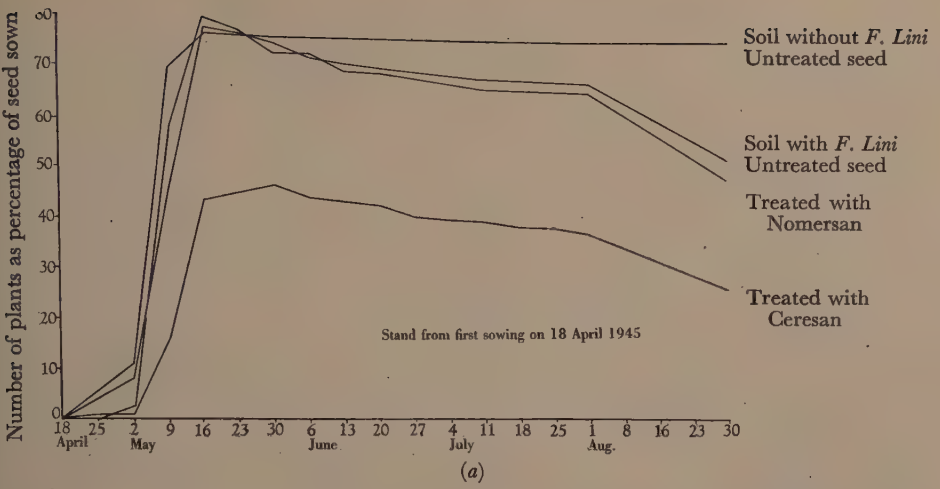
in the very early stages of germination, and there was another marked drop in the number of surviving plants during the 6th–7th week after sowing in the latter half of June, and again in the first part of August, but the older plants were not as rapidly killed as the younger ones and there was a short time lag. During periods of rather dry weather with bright sunshine, the soil temperatures are higher than in dull or wet weather. That a relatively high soil temperature is an important factor in favouring infection by *F. Lini* was shown by Jones and Tisdale (1922) and has been fully confirmed by many other investigators whose work has been summarized by Millikan (1945).

In 1945 an attempt was made to obtain more accurate information on the relation between soil temperature and infection by *F. Lini*, and for this purpose daily readings of the maximum and minimum soil temperatures were obtained at a depth of about half an inch, the level at which the infection of the plants generally occurs. At the same time, at the request of the Ministry of Supply, the fungicide Ceresan U 564 was tested, Nomersan also being used in other plots to give a standard of comparison.

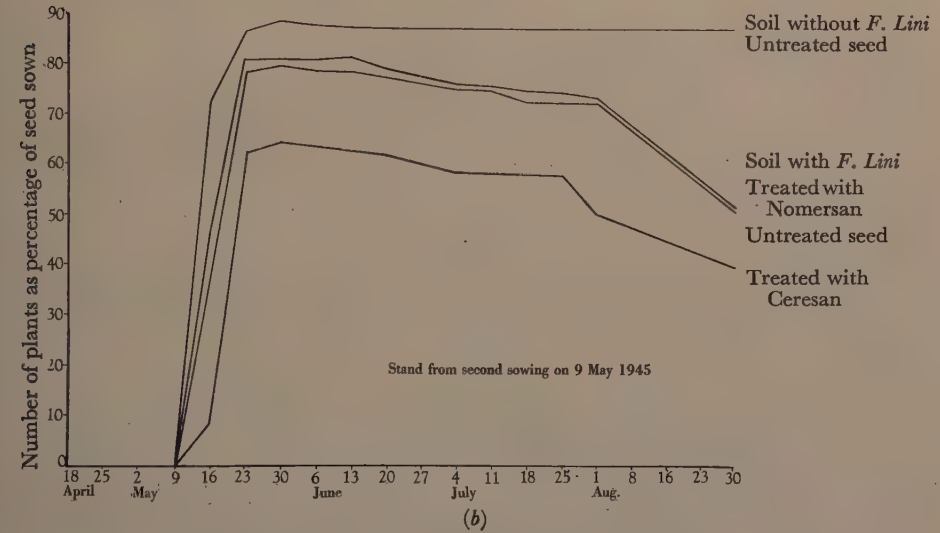
The same infected soil, now in its fourth successive year under flax, was sown with La Plata seed which was free from all disease organisms except 0·5 % of *Polyspora Lini*. Plots were sown with untreated seed, seed dressed with 0·6 % Nomersan applied as a dry powder and seed treated with an 8 % solution of Ceresan U 564 by the short-wet method (Muskett & Colhoun, 1943). At the same time similar seed, not treated with any fungicides, was sown in another bed which had not previously grown flax and was therefore free from *Fusarium Lini*. Two sowings were made, the first on 18 April 1945 and another, three weeks later, on 9 May 1945. All the plots for each sowing were duplicated. The rate of sowing was approximately equivalent to fifty pounds per acre.

The weather was very cold and dry at the time of the first sowing, and during the first three weeks there were frequent ground frosts and occasional hail and sleet showers, but just before the second sowing the weather became warmer with showers and sunny periods, though frost occurred as late as 27 May 1945. As might have been expected, the seeds of the first sowing germinated much more slowly than those of the second sowing (Text-fig. 2), they showed more evidence of frost damage to the cotyledons, and the percentage of germination was lower. Nevertheless, the germination rate was much higher than it had been in the same bed the previous year, owing probably to the fact that the cooler weather was unfavourable to attack by wilt disease.

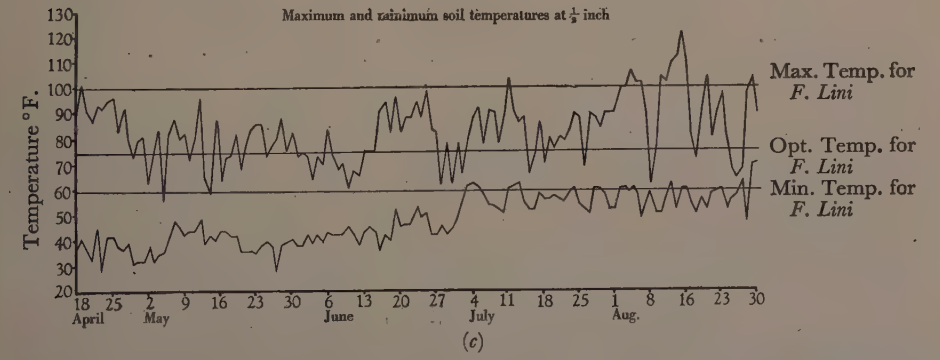
The curves (Text-fig. 2) representing the number of living plants in the two sowings, counted every week, show a striking parallelism as well as some significant differences. In both, there was no falling off in the stand of plants growing in the control plots free from *F. Lini*, except in the seedling stage and this was due entirely to *Polyspora Lini*. The number of living plants growing in soil infected with *Fusarium Lini*, on the other hand, showed a continuous decline which was particularly marked during the hot weather in August. The symptoms were similar to those for wilt disease, but, in addition, the incidence of disease due to *Polyspora Lini* was also


Number of plants as percentage of seed sown
Soil without F. Lini
Untreated seed
Soil with F. Lini
Untreated seed
Treated with
Nomersan
Treated with
Ceresan
Stand from first sowing on 18 April 1945
18 25 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 16 23 30
April May June July Aug.

(*a*)


Number of plants as percentage of seed sown
Soil without F. Lini
Untreated seed
Soil with F. Lini
Treated with
Nomersan
Untreated seed
Treated with
Ceresan
Stand from second sowing on 9 May 1945
18 25 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 16 23 30
April May June July Aug.

(*b*)


Maximum and minimum soil temperatures at ½ inch
Temperature °F.
Max. Temp. for
F. Lini
Opt. Temp. for
F. Lini
Min. Temp. for
F. Lini
18 25 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 16 23 30
April May June July Aug.

(*c*)

Text-fig. 2. (*a*) Graph to show relative stand of treated and untreated seed in wilt-infected soil and of untreated seed in healthy soil. First sowing, 18 April 1945. (*b*) As above. Second sowing, 9 May 1945. (*c*) Maximum and minimum soil temperatures at a depth of half an inch during period of growth of 1945 crop.

greater than in the control plots. Most of the older plants were infected with both fungi. Judged from the large number of isolations which were made, the *Polyspora* was at first confined to the leaves and to localized, superficial areas on the stem, while the *Fusarium* spread through the internal tissues of the stem and root. Since *Polyspora* infection alone did not prove fatal except for a few seedlings in the control plots, the main cause of the death of the plants in the other plots must be ascribed to *Fusarium Lini*. Some allowance must, however, be made for the decline in the fertility of the soil after four successive years under flax, and for the possible accumulation in the soil of other organisms inimical to flax.

The curves for the Ceresan treatment are very low in both sowings (Text-fig. 2). Colhoun (1945) has shown that treatment with Ceresan has the effect of lowering the percentage of viable seeds in subsequent storage, and that the higher the moisture content of the seed before treatment, the earlier this effect becomes apparent. These facts, no doubt, account for the results obtained in the present investigation where the moisture content of the seed before treatment was 8·1 % and the period in store was four to seven weeks. The test for Ceresan was therefore not a fair one. It has proved a valuable fungicide when the moisture content of the seed is low and the storage period is short (Muskett & Colhoun, 1943, 1944). That it provides particularly useful protection against stem break caused by *Polyspora Lini* was confirmed by a close examination of all the plants in all the plots five and eight weeks after sowing.

In both sowings, the results for the untreated seed and the seed dressed with Nomersan grown in wilt-infected soil are very close and follow the same general trend as the curve for Ceresan, but the falling off in the stand is a little steeper, probably on account of the greater incidence of infection with *Polyspora*, which in turn increases severity of attack by *Fusarium Lini*. There was a slight superiority in the germination of the seed treated with Nomersan in both sowings (Text-fig. 2), but this was not nearly so marked as in 1944. The weather in 1944 favoured attack by *F. Lini* in the early stages of germination, while in 1945 the weather was unusually cold in the early part of the summer, and the optimum conditions for infection did not occur until the plants were maturing, when seed dressings could not be expected to yield much protection.

Tisdale (1917) and Jones and Tisdale (1922) have shown that the critical soil temperature below which infection by *F. Lini* does not occur is about 57·2° F., that the optimum temperature for wilting lies between 75·2° F. and 82·4° F. and that infection does not occur above 96·4° F. These temperatures have been marked on the graph (Text-fig. 2) showing daily maximum and minimum soil temperatures at half an inch depth in the experimental plots, the lower value being taken for the optimum because work by Edwards (1945) suggests that this figure is the more accurate for the Aberystwyth isolates. Although the soil temperatures during 1945 were such that some infection would have been possible from the time of the first sowing, it is probable that the optimum temperature for infection was reached only for relatively short daily periods until at least the middle of June, and the soil temperatures remained low at night until the beginning of July. It was only during

the earlier part of August that the temperature requirements for infection by *F. Lini* fell squarely within the range of the maximum and minimum soil temperatures. The decline in the stand in the plots with soil containing *F. Lini* shows a distinct correlation with the soil temperatures, the higher temperatures leading to attack and destruction of the plants by this organism.

While wilt disease has developed each year from 1942 to 1945 in certain beds in the Botany Garden at Aberystwyth, the fungus has not spread in other beds with a different type of soil (Table 4) sown with infected seed.

Table 4. *Comparison of two types of soil in Botany Garden (after successive cropping to flax without addition of fertilizers)*

Soil		Loss on ignition	*p*H	Available phosphate	Available potash
Soil in which *F. Lini* spread:	A	14·5	4·21	0·0104	0·008
	B	17·5	4·25	0·0112	0·005
Soil in which *F. Lini* did not spread:	A	12·1	7·55	0·192	0·006
	B	12·4	7·96	0·192	0·008

The striking difference in the acidity of these soils was not the causal factor concerned in the spread of the fungus. Edwards (1945) has tested the Aberystwyth isolates on a *p*H range from 3·0 to 11·0 and has found that the growth is best on alkaline media with an optimum at *p*H 7·5. This is in part agreement with Anderson (1925), who found that the optimum was *p*H 5 in two cases and *p*H 7 in another, and with Bolley (1901 *a*), who stated that the fungus makes most rapid growth upon a rich humus and seems to be most destructive on strongly alkaline land. The more important factor favouring growth of *F. Lini* through one of the soils was probably its higher organic content, which not only provided a rich nutrient substrate for the fungus, but in giving a much darker colour to the soil ensured a higher soil temperature, which on sunny days was up to 10° C. above that in the other type of soil.

Although the methods used in the present investigation are remote from standard agricultural practice, the main conclusion, that *F. Lini* may cause severe damage to the flax crop even under the conditions of the British climate, may be of interest.

Summary

The occurrence and symptoms of wilt disease of flax caused by *Fusarium Lini* in experimental plots at Aberystwyth in 1942–5 are described. The source of infection was the Canadian seed of the variety Redwing.

Isolations of the fungus were made from seeds, stems and roots of diseased plants. Pathogenicity experiments using sterilized soil inoculated with these isolates showed that the fungus was a virulent parasite.

La Plata was very susceptible both in pathogenicity experiments and in the field. Redwing was fairly susceptible and Bison, although it suffered severely from the disease, was more resistant.

It was confirmed that flax plants can be attacked at any stage of development and that the incidence of wilt disease is closely correlated with suitable soil temperatures. When the plants were attacked in Aberystwyth, the disease was usually associated with infection by *Polyspora Lini*.

Seed dressings give considerable protection against infection during the early stages of germination, but are not so effective against attack on older plants. They may be a useful supplement to the more promising method of control, the breeding of resistant varieties of flax.

My thanks are due to Prof. G. E. Blackman for flax seed, to the Imperial Chemical Industries Ltd. for Nomersan and Agrosan G, and the Ministry of Supply for the fungicide Ceresan U 564 manufactured by Bayer Products Ltd., to Captain David Jones for meteorological data (except 27–30 May 1944), Mr R. O. Davies for the soil analysis and to Dr W. L. Gordon, Dominion Laboratory of Plant Pathology, Winnipeg, for the identification of the Fusariums.

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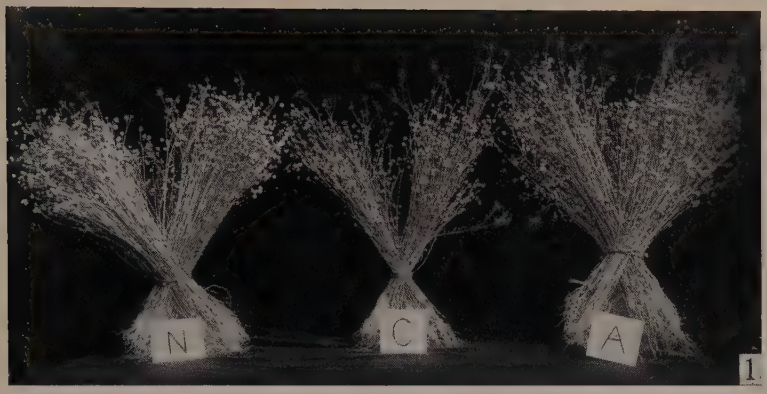
N
C
A
1

C
N.T
2

C
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EXPLANATION OF PLATE XIII

Fig. 1. Yields from plots of similar size in wilt-infected soil, 1944. *N*, seed treated with Nomersan; *C*, untreated seed; *A*, seed treated with Agrosan G.

Fig. 2. Yields from two rows of first sowing, 1945. *C*, untreated seed in healthy soil; *U*, untreated seed in wilt-infected soil; *Ce*, seed treated with Ceresan U 564 in wilt-infected soil; *N*, seed treated with Nomersan in wilt-infected soil.

Fig. 3. Yields from two rows of second sowing, 1945. Lettering as for fig. 2.

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NOTE ON THE OCCURRENCE OF SPECIES OF *OIDIODENDRON* ROBAK IN BRITAIN

By G. SMITH, *London School of Hygiene and Tropical Medicine*

The genus *Oidiodendron* was erected by H. Robak (1932) on three species which were all found growing on ground wood-pulp in Norwegian mills. The original three species are *O. nigrum*, *O. fuscum* and *O. rhodogenum*, the last being readily distinguished by its production of a blood-red diffusible pigment in wort agar cultures. Later, Robak (in Melin & Nannfeldt, 1934, p. 440) described a fourth species, *O. griseum*, and a further addition to the genus was made by von Szilvinyi (1941) with his *O. flavum*.

The genus is characterized by erect, arborescent conidiophores, with branching always monopodial, and by the differentiation of the terminal branches, from the tip inwards, into conidia. Superficially the fructifications resemble, except for their smaller size, those of *Cladosporium* (*Hormodendron*), but the method of spore production relates the genus to *Oidium* and *Torula* Pers.

So far as I can ascertain there have been, up to the present, no records of *Oidiodendron* for Britain.*

Between 1923 and 1930 a considerable number of fungi, mostly Hyphomycetales, were collected for biochemical studies in the research laboratories of Nobel's Explosives Co. Ltd., at Ardeer, and in 1931 the collection of cultures was transferred to the London School of Hygiene and Tropical Medicine. Two of the cultures, both of which were catalogued as '*Hormodendron* or ?*Cladosporium*', obviously differed in cultural characteristics from typical *Cladosporium herbarum*, but no attempt was made to identify them until, recently, one of them was shown to have interesting biochemical properties.

Culture Ag 109. This was isolated by the late J. H. V. Charles from a lichen on a wooden post, in December 1926. It is a typical strain of *O. rhodogenum* Robak. Growth on all culture media is very slow, almost velvety or tufted floccose, pale grey, with overgrowth of dirty white sterile mycelium. On corn-meal agar or wort agar the whole mass of medium is gradually coloured blood-red. On other media pigment production is sparse and spasmodic.

Culture Ag 112. Isolated by the late J. H. V. Charles, April 1928, from gun cotton at Ardeer. Growth is very slow, grey to fuscous, powdery, with some dirty brown pigment in the medium. It agrees well with *O. fuscum* Robak.

Another strain of *O. fuscum* has recently been received from Dr A. Burges, Cambridge, amongst a batch of *Penicillium* cultures for identification. It was isolated in October 1945, from the surface humus in a pine plantation

* Since this Note was submitted for publication Dennis and Wakefield (*Trans. Brit. Mycol. Soc.* 1946, XXIX, 141) have described a British strain of *O. fuscum* Robak.

at Wangford Warren, near Brandon. Dr Burges reports that he has, in addition, three other isolations from the same locality.

In view of the similarity of this genus, in gross appearance of the conidial fructifications, to *Cladosporium*, it seems probable that a search through the records of *Cladosporium* would bring to light other instances of the occurrence of species of *Oidiodendron* in Britain.

I am greatly indebted to Mr E. W. Mason, who identified the strain Ag 112 as *Oidiodendron*, and drew my attention to Robak's paper.

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NOTES ON THE DIE-BACK OF OAK CAUSED BY *COLPOMA QUERCINUM* (FR.) WALLR.

By E. S. TWYMAN, *Department of Botany, University of Birmingham*

(With Plate XIV and 3 Text-figures)

1. Introduction

Colpoma quercinum (Fr.) Wallr. is a phacidiaceous inoperculate, discomycete, causing a die-back of young oak trees, coppiced oak and the smaller terminal branches of older trees. Its taxonomy has been discussed by von Höhnel (1917) and by Nannfeldt (1932). The brothers Tulasne (1853) and Brefeld (1891 *a*, *b*) have described the associated conidia and Fries (1823), Rehm (1896), Neger and Dawson (1907) and Nannfeldt (1932) have described the ascocarp. The pathology of the fungus was dealt with by Frank (1880) and, in greater detail, by Neger and Dawson (1907).

2. The ascocarp

Adequate photographs and drawings of apothecia, asci and ascospores do not exist beside descriptions of the species, and Pl. XIV, fig. 1, shows a few mature apothecia as they appear in May, June and July. They usually occur on dead twigs and branches, but occasionally they appear on the diseased side of a living branch. Nannfeldt (1932) describes the form of the apothecium, the hymenium of which consists of clavate asci (130–150 × 9–10 μ) with bluntly pointed apices and paraphyses with curled tips (Pl. XIV, fig. 2). The asci contain eight hyaline elongated spores (15–115 × 1·5 μ). The mode range of ascospore length is 40–65 μ. Rehm's (1896) measurements are 90 × 1·5 μ.

The ascospores are violently discharged, a phenomenon previously observed in other discomycetes and pyrenomycetes by Jones (1925), Ingold (1928) and Buller (1909; 1934). The maximum height to which spores are discharged in still air is 14·5 mm., while most of them are ejected to heights up to 6·5 mm.

3. The conidia

(*a*) *Collected material*

The conidial apparatus has been described only in association with the ascocarps. It forms a melanconiaceous acervulus, but it cannot be identified with any separately named member of the Melanconiaceae. Since observations of its structure do not precisely correspond with those of the brothers Tulasne (1853) and of Brefeld (1891*a*, *b*), a complete description is given.

While the acervuli appear on newly infected twigs before the apothecia, they are usually also closely associated with young apothecial rudiments. The shape of an acervulus is that of a truncated cone (Text-fig. 1 A) with a basal layer of pseudoparenchyma, 0·04–0·05 mm. in thickness. From

the centre of this basal layer the pseudoparenchymatous cone extends upwards towards the opening and sometimes protrudes through it (Text-fig. 1 A). This gives a bilocular appearance to a vertical section. Conidiophores (50μ long) arise from the basal parenchyma on each side of the core. Beneath the periderm, immediately above the conidiophores and conidia and extending from the opening to the edge of the basal parenchyma, is a thin weft of loose hyphae (Text-fig. 1 A, C and D, *e*) which can be left in position by carefully removing the periderm. Under this thin layer of fungus tissue, the five to seven locules of the acervulus appear radially arranged round the dark brown central core of pseudoparenchyma (Text-fig. 1 B, C and D). The locules are delimited from the host tissue by a thin layer of black pseudoparenchyma. The conidia are extruded from the opening in the ruptured periderm as a cream or reddish globular mass.

(*b*) *Development in culture*

Oat sucrose, maize and oat agars are the best media for the formation of sporulating acervuli at room temperature. On these they appear after seven to eight weeks if the cultures are given an initial incubation at 25° C. for fourteen days.

The acervulus originates as a small hemispherical tuft of loosely interwoven hyphae (1·0–2·0 × 0·5–1·0 mm.) the outer layers of which gradually become compacted to form a wall of pseudoparenchyma. This wall is differentiated into three regions: (*a*) a layer of loosely interwoven hyphae some of which are brown and 5–10μ broad while others are finer and colourless (Text-fig. 1 F, *g*), (*b*) a layer of dense pseudoparenchyma formed of dark brown hyphae (Text-fig. 1 F, *h*), and (*c*) a layer of compact colourless hyphae that give rise to the conidiophores (Text-fig. 1 F, *k*). After seven or eight weeks the outer layers of the acervulus rupture (Text-fig. 1 G) and spores issue from the top as a cream, globular mass which turns red or pink.

(*c*) *The conidia*

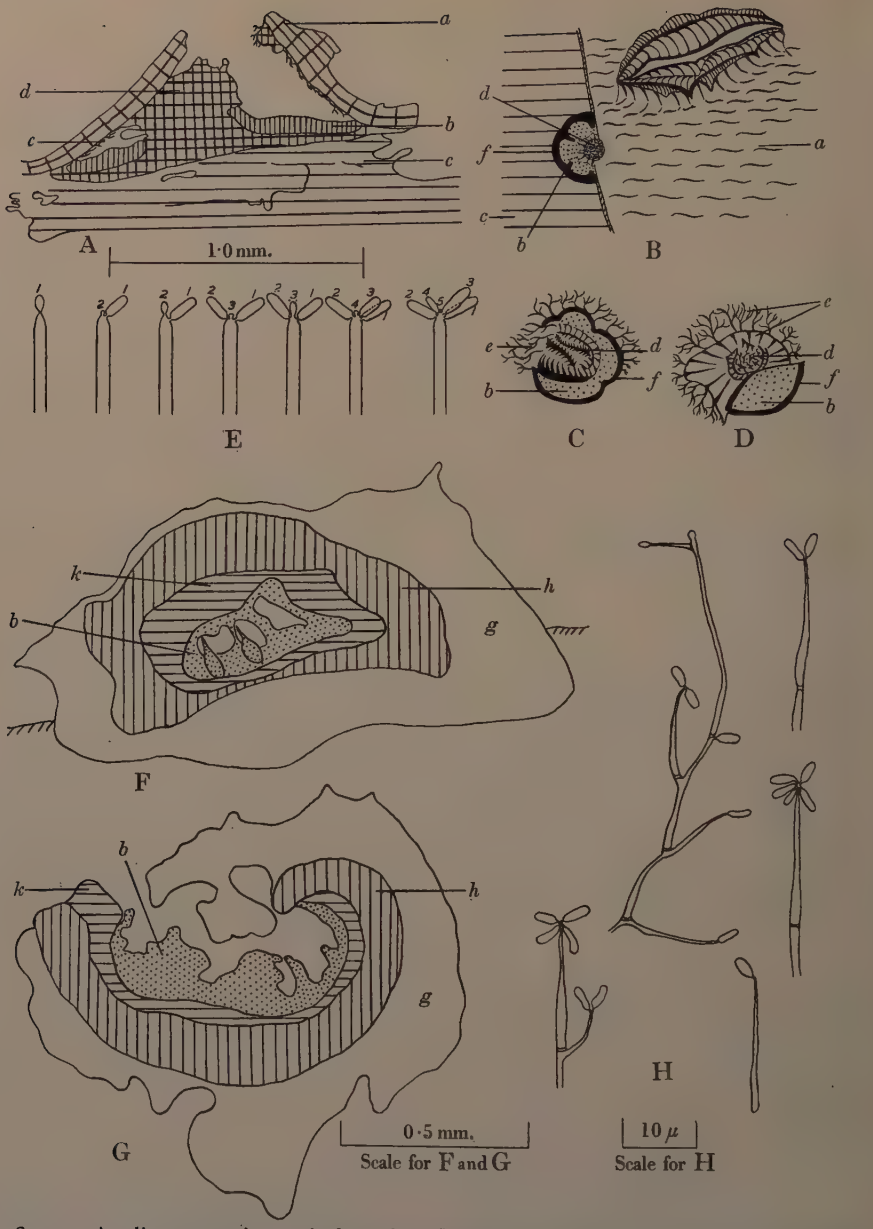
The conidia of *Colpoma quercinum* are unicellular, hyaline, cylindrical or slightly curved and rounded at each end. Measurements of the conidia given by three authorities are:

Brefeld	7–8 × 1·5μ
Saccardo	8 × 1·5μ
Tulasne	6·5μ

During this investigation 1600 conidia were measured. The lengths of spores produced on agar cultures had a mode range of 3·9–4·8μ with a variation of 2·4–7·3μ. The mode range of the length of spores from naturally infected material was 4·4–5·3μ.

The disposition of the conidia on the conidiophores is described and figured by Brefeld (1891 *b*). My drawings are shown in Text-fig. 1 H. From observations, it is suggested that the conidia arise in basipetal succession, as shown in Text-fig. 1 E.

The conidiophores are very variable in length and may be branched or unbranched (Text-fig. 1 H). Sometimes numerous branched conidiophores



Text-fig. 1. A, diagrammatic vertical section through an acervulus of *Colpoma quercinum*: *a*, periderm; *b*, hymenium of conidiophores; *c*, infected cortex; *d*, pseudoparenchyma; *e*, thin weft of mycelium. B, diagrammatic surface view of an acervulus and apothecium of *C. quercinum*; the periderm and underlying fungal tissue have been removed from half the acervulus: *a*, periderm; *b*, hymenium of conidiophores and conidia; *c*, infected cortex; *f*, black pseudoparenchyma limiting acervulus from host. C and D, diagrammatic surface views of two acervuli showing the thin covering of fungal tissue (*e*) over the hymenium; other letters as in A and B. E, diagram showing the origin of conidia at the tip of a conidiophore: 1–5, order in which conidia arise. F, diagrammatic section through an acervulus developed on agar: *b*, hymenium of conidiophores and conidia; *g*, loosely interwoven hyphae; *h*, dark compact pseudoparenchyma; *k*, compact hyaline pseudoparenchyma. G, diagrammatic vertical section through a ruptured acervulus developed in culture; letters as in F. H, group of conidiophores.

and sterile hyphae become grouped together, forming an elongated conical structure which terminates in a few sterile hyphae (Pl. XIV, fig. 3). This is the coremial-like structure referred to by Brefeld (1891 *b*).

Despite repeated attempts, the conidia were not germinated on any of the following media: distilled water, turnip extract, maize extract, oatmeal extract, plain agar, maize extract agar, and clear malt extract agar. This agrees with the findings of Brefeld (1891 *a*). Attempts to determine if these spores functioned as spermatia were unsuccessful.

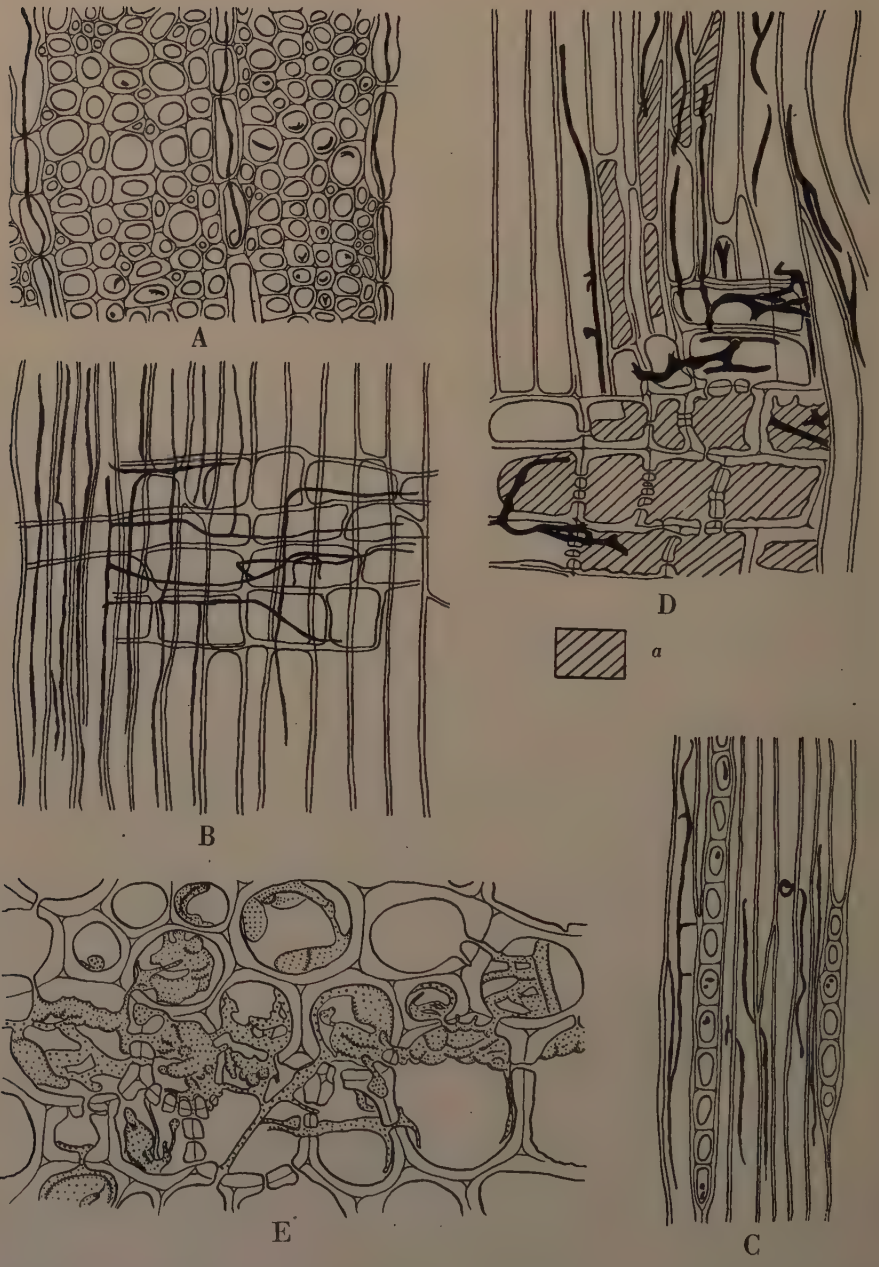
4. The mycelium of *Colpoma quercinum* in collected diseased wood

The distribution of mycelium in diseased wood was investigated by Cartwright's method (1929). Diagrams in Text-fig. 2 A, B and C show the appearance of typical mycelium in infected wood. The mycelium travels in a longitudinal direction in the vessels and tracheids and in a radial direction in the cells of the medullary rays. The direction in which the hyphae travel therefore seems to be determined by the shape of the cells in which they are growing. Black lines, formed by aggregated brown-walled, inflated hyphae filling the lumina of cells of the xylem and pith, are observed in the diseased wood (Text-fig. 2 E, and Pl. XIV, fig. 4). Similar lines produced by other fungi are described by Hiley (1919), Campbell (1934) and Wilkins (1936). Campbell considers the black line of *Armillaria mellea* to be the limiting edge of a sclerotium-like body immersed in the tissues of the host, but Wilkins (1936), working with *Ustulina*, found it associated both with the growing edge of the mycelium in the wood and irregularly distributed in the wood with no connexion with the growing edge. In *Colpoma quercinum* the black line was not associated with the growing edge of the mycelium, but was always found in diseased twigs bearing apothecia. If the periderm were removed, the line surrounded one or more apothecia (Pl. XIV, fig. 4), beneath which a pocket of diseased wood was found completely delimited by the black line. In longitudinal section the line descended radially into the wood and joined up with similar lines travelling in a longitudinal direction (Pl. XIV, fig. 4). These lines were not found within infected oak twigs (previously sterilized) bearing the conidial pustules. The line might be regarded therefore as the edge of a stroma bearing apothecia.

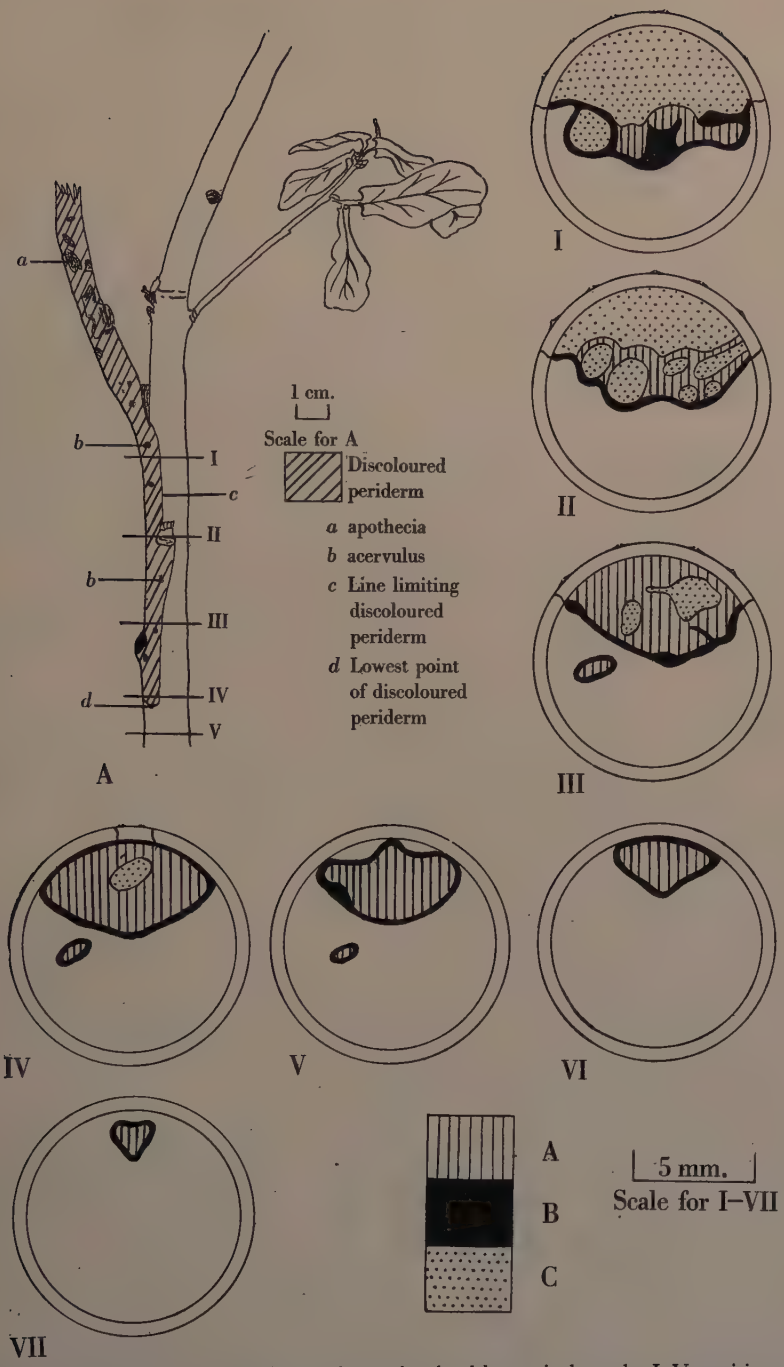
The mycelium of this fungus destroys the phloem and cortex, while the periderm remains free from attack. The relation between the mycelium in the xylem and in the phloem and cortex has yet to be determined.

5. The progression of the mycelium from infected to healthy branches

The actual mode of entry of *Colpoma quercinum* into the host is still a matter of conjecture, but there is evidence that infection takes place through wounds caused mechanically or by the depredations of insect larvae such as those of the moth *Tortrix viridana* (Neger & Dawson, 1907). The original diseased areas of this die-back usually occur on small twigs and the infection travels basally, entering the healthy parent branch and spreading towards



Text-fig. 2. A, transverse section of infected wood. B, radial section of infected wood. C, tangential longitudinal section of infected wood. D, radial section taken from light red brown region (see text): *a*, ligno-tannin complex. E, transverse section in the black line region of infected wood, showing the brown-walled, inflated hyphae. Hyphae black or stippled.



Text-fig. 3. A, diagram of infected lateral entering healthy main branch; I–V, positions where sections I–V were cut. I–VII, diagrams of transverse sections cut across twig A at points, 2·0, 4·3, 6·8, 9·0, 10·0 and 14·3 cm. respectively, below the junction of lateral with main branch; A, light red-brown region; B, dark red-brown region; C, pale highly infected region; sound wood is unshaded. (For further explanation see text.)

its apex and base. The latter progression of the disease in the host branch is most frequently encountered (Text-fig. 3 A). Several examples of this spread of infection have been examined and all conform to the same plan, so that a detailed account of only one of these will be given.

Text-fig. 3 A shows the external appearance of the specimen. The infected lateral branch bears apothecia, acervuli and discoloured periderm, while the diseased part of the main branch shows only acervuli and discoloured periderm.

As a result of an examination of seven transverse sections cut at intervals across the twig, four main regions were recognized: (1) sound wood (Text-fig. 3, I–VII, unshaded), (2) a narrow dark reddish brown region (Text-fig. 3, I–VII, B), (3) a wider lighter brown area (Text-fig. 3, I–VII, A), and (4) a pale region of highly infected wood (Text-fig. 3, I–IV, C). The consistency of the first three regions was hard, while that of the fourth was soft. The brown regions (Text-fig. 3 A and B), termed the gum barrier, cut off the highly infected area (Text-fig. 3 C) from the sound tissues. Microchemical tests on sections from the gum barrier showed the presence of lignin and tannin in the cells (Crocker, 1921; Haas & Hill, 1920). The brown substance was therefore termed a ligno-tannin complex. The difference in colour between the two brown regions was due to the relative proportion of cells filled with the ligno-tannin complex. Since no gum barrier was seen in uninfected twigs and as the greatest deposition of the complex is in the narrow region next to the sound wood, it may be assumed that the ligno-tannin complex is produced by the living tissues as a reaction to the advancing mycelium. The pale region (Text-fig. 3 C) contrasted with the gum barrier region in the softness and obvious decay of the wood. The difference between these two zones was attributed to the delignification of the cell walls and the digestion of the ligno-tannin inclusions in the cells of the infected tissues, since the microchemical tests for lignin and tannin gave negative results. Since hyphae were observed in some cells of the xylem containing the ligno-tannin complex, it is suggested that these products may be digested by the fungus (Text-fig. 2 D, *a*). Birkinshaw and Findlay (1940) give some indication of the method by which phenolic substances are digested.

6. Summary

1. *Colpoma quercinum* (Fr.) Wallr. is an inoperculate, phacidiaceous discomycete, causing a die-back of oak trees. The conidia of this fungus develop very easily in culture and occur on an acervulus not previously described in the literature of the Melanconiaceae. The conidia do not germinate and no sexual function can yet be assigned to them.

2. The distribution of the mycelium of *C. quercinum* is such that the hyphae travel in a longitudinal direction in the vessels and tracheids and in a radial direction in the medullary rays. Black lines are formed which are probably the limiting edges of stromata bearing apothecia.

3. The natural progression of the mycelium of the fungus from infected to healthy branches is usually basal. A gum barrier laid down between infected and healthy wood contains a ligno-tannin complex.

Fig. 1.

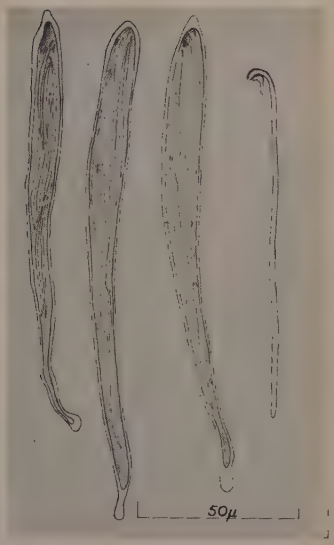


Fig. 2.

Fig. 3.

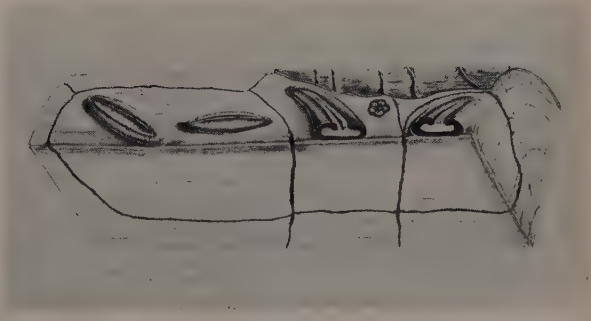


Fig. 4.

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EXPLANATION OF PLATE XIV

Fig. 1. Mature apothecia of *Colpoma quercinum.*
Fig. 2. Asci and a paraphysis of *C. quercinum.*
Fig. 3. Coremial-like structure found in acervuli of *C. quercinum* developed in culture.
Fig. 4. Part of a twig bearing apothecia, showing stromata limited by black lines.

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BIOMETRICAL RESEARCHES OF SECONDARY SPORES AND A STUDY OF THE MYCELIUM OF *PHOLIOTA ADIPOSA* FR., *P. HETEROCLITA* FR., *P. MUTABILIS* (SCHAEFF.) FR., *P. SPECTABILIS* FR. AND *P. SQUARROSA* (MULL.) FR.

By S. BATKO

(With 1 Text-figure)

I. Introduction

In the course of a study of secondary spores and the type of rot caused by species of *Pholiota* the results of some previous researches have proved very useful.

Cartwright (1929*b*) described the culture and secondary spores of *P. adiposa*. The decay and microscopical details of the mycelium of *P. squarrosa* on ash were recorded by Cartwright and Findlay (1942). Robak (1933) observed the fruit bodies of *P. mutabilis* in culture and described the type of rot produced by this fungus on wood pulp. Fruiting bodies of *P. heteroclita* on 2 % malt and of *P. squarrosa* were obtained on sterilized wheat grains by Cartwright and Findlay. Davidson, Campbell and Blaisdell (1938), confirming Bavendamms' hypothesis of the reaction of wood-decaying fungi grown on media containing small amounts of gallic or tannic acid, found that *P. adiposa* causes a white decay.

The writer's descriptions of the mycelia of species of *Pholiota* were based on those given by Snell (1922). The staining method for fungal mycelium described by Cartwright (1929*a*) proved very useful when hyphal measurements in wood had to be made.

II. Original investigations

For the studies described below, the following fungi were obtained from the Forest Products Research Laboratory, Princes Risborough, Bucks: *Pholiota adiposa*, 52A; *P. heteroclita*, 159; *P. mutabilis*, 49; *P. spectabilis*, 126; and *P. squarrosa*, 90. The writer wished to carry out biometrical researches on secondary spores of these five fungi because, so far as he was aware, no previous work of this nature had been published. The following biometrical constants have been calculated for each: the mean, the standard deviation, the coefficient of variation and their standard errors.

In August 1945 the fungi were transplanted on 5 % Kepler's malt agar and 2 % agar in boiling tubes, and exposed to diffuse light in the laboratory. A few months later, both aerial and submerged mycelium were examined under the microscope and the following observations were noted. *Pholiota adiposa*, *P. mutabilis*, *P. squarrosa* formed abortive fruit bodies in culture. *P. spectabilis* formed typical fruit bodies (Fig. 1).

Pholiota adiposa

Aerial mycelium. Hyphae, secondary spores and oidia hyaline; clamp connexions present; secondary spores ellipsoidal, ovate, or sometimes almost orbicular; walls of spores thin; crystals present. The typical secondary spores and oidia were measured separately.

Submerged mycelium. Hyaline; secondary spores and oidia are found in the submerged mycelium, but not so profusely as in the aerial mycelium; clamp connexions rare; secondary spores; ellipsoidal, ovate, sometimes almost orbicular; very occasionally chlamydospores occur; crystals present.

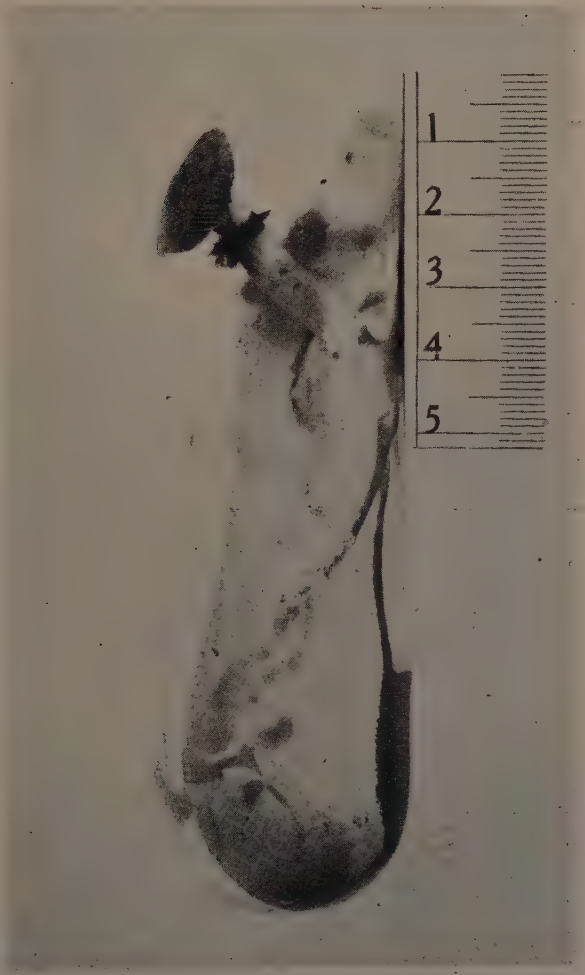

Fig. 1. *Pholiota spectabilis* fruiting on 5% malt, 2% agar after 4½ months. The scale is given in cm.

Pholiota adiposa. Average size of secondary spores

Aerial mycelium				Submerged mycelium			
Length		Breadth		Length		Breadth	
μ	No.	μ	No.	μ	No.	μ	No.
5	12	3	5	4	2	3	12
6	34	4	76	5	24	4	57
7	44	5	19	6	37	5	30
8	9	Total	100	7	24	6	1
9	1			8	11	Total	100
Total	100			9	1		
				10	1		
				Total	100		

Average size of oidia

Aerial mycelium				Submerged mycelium			
Length		Breadth		Length		Breadth	
μ	No.	μ	No.	μ	No.	μ	No.
7	6	2	69	5	1	1·5	2
8	24	3	31	6	1	2	87
9	38	Total	100	7	11	2·5	5
10	26			8	20	3	6
11	6			9	28	Total	100
Total	100			10	33		
				11	5		
				12	1		
				Total	100		

Biometrical constants. Size of secondary spores

Length in μ			Breadth in μ		
Mean	Standard deviation	Coefficient of variation %	Mean	Standard deviation	Coefficient of variation %
A. Aerial mycelium					
6·5±0·08	0·85±0·06	13·1±0·94	4·1±0·05	0·47±0·03	11·5±0·82
B. Submerged mycelium					
6·2±0·11	1·09±0·08	17·6±1·28	4·2±0·06	0·64±0·04	15·4±1·14

Size of oidia

Length in μ			Breadth in μ		
Mean	Standard deviation	Coefficient of variation %	Mean	Standard deviation	Coefficient of variation %
A. Aerial mycelium					
9·0±0·09	0·99±0·07	11·0±0·78	2·3±0·05	0·46±0·03	20·1±1·47
B. Submerged mycelium					
9·0±0·12	1·23±0·09	13·7±0·98	2·1±0·03	0·27±0·02	12·8±0·92

Pholiota heteroclita

Aerial mycelium. Single hyphae hyaline, but yellowish in mass; clamp connexions frequent; no secondary spores formed.

Submerged mycelium. Hyaline; clamp connexions present, but not common; no secondary spores formed.

Pholiota mutabilis

Aerial mycelium. Single hyphae hyaline, but whitish in mass; secondary spores absent; crystals frequent and mainly within the hyphal cells.

Submerged mycelium. Hyphae hyaline; no secondary spores formed; crystals formed within and outside the mycelium; crystals less frequent than in the aerial mycelium.

Pholiota spectabilis

Aerial mycelium. Single hyphae hyaline, but whitish in mass; clamp connexions frequent; secondary spores numerous, almost orbicular in shape. About 50 % of the spores have thick walls (approximately 1–2 μ in thickness); crystals formed both inside and outside the hyphae, but not frequent.

Submerged mycelium. Hyphae hyaline; secondary spores abundant, thin-walled; clamp connexions not abundant; crystals formed both inside and outside the hyphae.

Pholiota spectabilis. Average size of secondary spores

Aerial mycelium				Submerged mycelium			
Length		Breadth		Length		Breadth	
μ	No.	μ	No.	μ	No.	μ	No.
9	2	8	4	12	6	9	1
10	31	9	22	13	5	10	2
11	12	10	32	14	14	11	3
12	13	11	7	15	36	12	11
13	19	12	14	16	18	13	20
14	8	13	8	17	9	14	22
15	8	14	5	18	10	15	31
16	2	15	7	19	—	16	6
17	2	16	1	20	2	17	3
18	3	Total	100	Total	100	18	1
Total	100					Total	100

Biometrical constants. Size of secondary spores

Length in μ			Breadth in μ		
Mean	Standard deviation	Coefficient of variation %	Mean	Standard deviation	Coefficient of variation %
A. Aerial mycelium					
12·1 ± 0·18	1·83 ± 0·13	15·1 ± 1·09	10·9 ± 0·2	2·0 ± 0·14	17·8 ± 1·29
B. Submerged mycelium					
15·3 ± 0·16	1·64 ± 0·12	10·7 ± 0·76	13·9 ± 0·16	1·57 ± 0·11	11·3 ± 0·80

Pholiota squarrosa

Aerial mycelium. Single hyphae hyaline or yellowish; mycelium in the mass brown yellowish; secondary spores very rare; clamp connexions frequent.

Submerged mycelium. Hyaline; thin-walled secondary spores present; variable in form, usually pear-shaped, but others were ellipsoidal or orbicular, and some narrowed in the middle; clamp connexions present; crystals formed.

Pholiota squarrosa. Average size of secondary spores. Submerged mycelium

Length μ	No.	Breadth μ	No.
6	1	5	39
7	5	6	40
8	4	7	17
9	7	8	3
10	21	9	1
11	17	Total	100
12	16		
13	7		
14	5		
15	4		
16	2		
17	3		
18	3		
19	—		
20	2		
21	1		
22	1		
23	—		
24	1		
Total	100		

Biometrical constants. Size of secondary spores. Submerged mycelium

Length in μ			Breadth in μ		
Mean	Standard deviation	Coefficient of variation %	Mean	Standard deviation	Coefficient of variation %
11·9±0·33	3·31±0·23	27·9±2·12	5·9±0·09	0·86±0·06	14·6±1·05

THE MYCELIUM OF SPECIES OF *PHOLIOTA* IN BEECH WOOD

The beech blocks were put in the flasks containing the cultures of five *Pholiota* species and left exposed there to fungal attack for about four and a half months. Afterwards they were removed, sections stained with safranin and picroaniline blue and examined under the microscope. The following results were obtained:

(1) *Pholiota adiposa.* The blocks after removal from the flasks were found to be badly decayed. The rot was white, the timber being very soft, with mycelium distributed throughout. Seventeen sections were used for investigation, comprising radial, tangential and transverse sections. Twenty bore-holes dispersed in the various tissue were measured. The mean

dimensions are as follows: $6{\cdot}7 \times 5{\cdot}8\mu$. Besides these, seven very large ones were observed. They measured: $90 \times 70\mu$, $100 \times 75\mu$, $70 \times 70\mu$, $120 \times 80\mu$, $110 \times 70\mu$, $120 \times 110\mu$, $110 \times 100\mu$. Boring occurred both through the walls and pits. Clamp connexions occur. Diameter of hyphae $1–2\mu$.

(2) *Pholiota heteroclita.* The cultures in flasks became contaminated and no records were made.

(3) *Pholiota mutabilis.* For microscopical researches thirty-five sections were used. The mean of eleven bore-holes is $4{\cdot}1 \times 2{\cdot}8\mu$. There are, however, numerous very small bore-holes (about 1μ in diameter) and these have not been included in the general mean. The rot was white. Clamps were present. Hyphae from 1 to 3μ in diameter.

(4) *Pholiota spectabilis.* To describe mycelium twelve sections were used. The bore-holes were generally small (about 2μ in diameter), rarely larger bore-holes can be met with. The rot is white. Clamps present. Unlike the other four species of *Pholiota*, this fungus does not attack the pits to any appreciable extent. Hyphae $1–4\mu$ in width. Secondary spores present. Some of them have thick walls.

Pholiota spectabilis. Average size of secondary spores. Mycelium in wood

Length μ	No.	Breadth μ	No.
7	1	7	1
8	—	8	1
9	6	9	16
10	17	10	40
11	20	11	22
12	18	12	15
13	24	13	3
14	9	14	1
15	4	15	1
16	1		
Total	100	Total	100

Biometrical constants. Size of secondary spores. Mycelium in wood

Length in μ			Breadth in μ		
Mean	Standard deviation	Coefficient of variation %	Mean	Standard deviation	Coefficient of variation %
$11{\cdot}8 \pm 0{\cdot}16$	$1{\cdot}65 \pm 0{\cdot}12$	$14{\cdot}1 \pm 1{\cdot}01$	$10{\cdot}5 \pm 0{\cdot}12$	$1{\cdot}24 \pm 0{\cdot}09$	$11{\cdot}9 \pm 0{\cdot}85$

(5) *Pholiota squarrosa.* In order to obtain accurate figures, the holes were separately measured for each type of cell. Thirty-two sections were used:

(*a*) *Vessels.* The mean of eighteen bore-holes was $8{\cdot}0 \times 6{\cdot}4\mu$.

(*b*) *Fibre tracheids.* The mean of twenty-two bore-holes was $6{\cdot}7 \times 5{\cdot}4\mu$.

(*c*) *Fibres.* The mean of twenty-two bore-holes was $3{\cdot}9 \times 2{\cdot}5\mu$.

(*d*) *Medullary rays and parenchyma.* The mean of ten bore-holes was $6{\cdot}8 \times 5{\cdot}8\mu$.

The general mean (for all types of cell) $6{\cdot}3 \times 5{\cdot}0\mu$. The numerous small bore-holes ($1–2\mu$ in diameter), especially in fibres and parenchyma, have

not been included in the general mean. Clamp connexions occur, occasionally proliferating. Hyphal diameter 1–3 μ. Boring through walls and pits. Mycelium uniformly distributed throughout. The colour of the rot is white.

Method of determining significance of results

(1) *Significance of differences between means.* The significance of the differences has been checked by the following formula:

$$\frac{m_1 - m_2}{\sqrt{(\sigma_1^2 + \sigma_2^2)}} \text{ (A)}.$$

m_1 and m_2 are the mean values to be compared. σ_1 and σ_2 are standard errors of two means. $\sigma_1^2 = s_1^2/n_1$, $\sigma_2^2 = s_2^2/n_2$, s_1, s_2 are standard deviations of the groups from which the means are derived. n_1, n_2 are number of results in two groups, here $n_1 = n_2 = 100$. If the ratio (A) exceeds 2, it may be considered that the difference is significant; if the ratio is below 2, then the difference is not significant, but is such as might reasonably have been obtained from repeated sampling in a single population only.

Conclusions

Mean size of secondary spores

	On aerial hyphae		On submerged hyphae		On hyphae in wood	
Fungus	Length μ	Breadth μ	Length μ	Breadth μ	Length μ	Breadth μ
P. adiposa						
Secondary spores	6·5	4·1	6·2	4·2	—	—
Oidia	9·0	2·3	9·0	2·1	—	—
P. spectabilis	12·1	10·9	15·3	13·9	11·8	10·5
P. squarrosa	—	—	11·9	5·9	—	—

Pholiota adiposa. The difference between the size of secondary spores of the aerial and submerged mycelia is not significant.

The difference between the size of oidia of the aerial and submerged mycelia is not significant.

Pholiota spectabilis. The difference between the size of secondary spores of the aerial and submerged myceliu m is significant.

The difference between the size of secondary spores of the aerial mycelium and the mycelium in wood is significant.

The difference between the size of secondary spores of the submerged mycelium and the mycelium in wood is significant.

Pholiota adiposa and *P. spectabilis.* The difference between the size of secondary spores of the aerial mycelium of *P. adiposa* and *P. spectabilis* is significant.

The difference between the size of secondary spores of the submerged mycelium of *P. adiposa* and *P. spectabilis* is significant.

Pholiota adiposa and *P. squarrosa.* The difference between the size of secondary spores of the submerged mycelium of *P. adiposa* and *P. squarrosa* is significant.

The difference between the size of secondary spores of the aerial mycelium of *P. adiposa* and of the submerged mycelium of *P. squarrosa* is significant.

Pholiota spectabilis and *P. squarrosa*. The difference between the mean length of secondary spores of the aerial mycelium of *P. spectabilis* and of the submerged mycelium of *P. squarrosa* is not significant.

The difference between the mean breadth of secondary spores of the aerial mycelium of *P. spectabilis* and of the submerged mycelium of *P. squarrosa* is significant.

The difference between the size of secondary spores of the submerged mycelium of *P. spectabilis* and *P. squarrosa* is significant.

The difference between the mean length of secondary spores of the submerged mycelium of *P. squarrosa* and of the mycelium in wood of *P. spectabilis* is not significant.

The difference between the mean breadth of secondary spores of the submerged mycelium of *P. squarrosa* and of the mycelium in wood of *P. spectabilis* is significant.

(2) Secondary spores of *P. squarrosa* are very variable in shape and in length. They have the largest coefficient of variation of the length of all species investigated.

(3) The following is the arrangement of the fungi according to size of bore-holes (beginning with the largest): (1) *P. adiposa*, (2) *P. squarrosa*, (3) *P. mutabilis* and (4) *P. spectabilis*.

Summary

The secondary spores of five *Pholiota* spp. are described and the statistical significance of their differences in size is discussed.

I am much obliged to Dr F. Y. Henderson, Director of Forest Products Research, for kind permission to carry on research in his Laboratory, to Miss Pettifor of the Timber Mechanics Section and to Messrs K. St G. Cartwright and W. P. K. Findlay for valuable suggestions, and to Mr E. C. Badcock for kind help and assistance during my work in the Mycological Section.

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NEW AND INTERESTING PLANT DISEASES

By W. C. MOORE, *Plant Pathology Laboratory, Harpenden*

(With Plates XV–XVII)

25. Mildew (*Oidium Valerianellae* Fuckel) on Corn Salad

In November 1945 and again in the spring of 1946 Dr Katharine H. Johnstone kindly sent me specimens of corn salad (*Valerianella olitoria* Poll.) growing in her garden at Helland Bridge, near Bodmin. The plants had been raised from seed of an unnamed variety, probably of North American origin. Some of the lower stem leaves were brown and withered, and bore pycnidia of a species of *Phyllosticta*, while on the younger leaves there were patches of mildew which, to the naked eye, strongly suggested a downy mildew, though on closer examination it proved to be a species of *Oidium*. The mildew was very sparse on the specimens sent on 9 November and 26 March but, on those received 10 April 1946, when the plants had 'bolted' and begun to flower, it was present as conspicuous white, fluffy flecks on the upper surfaces of the leaves. It was also fruiting, though less obviously, on the undersides of the foliage leaves, on the stems, and on the small bracts surrounding the flowers. The conidiophores were simple, often grouped in small tufts, and bore chains of up to at least six long-elliptic, oblong, or barrel-shaped conidia, ranging in size from $27–39 \times 13–21\,\mu$ (average of thirty conidia $32{\cdot}8 \times 17{\cdot}8\,\mu$).

No powdery mildew has been recorded in Britain on *Valerianella*, but in August 1943 Dr P. H. Gregory gave me some specimens of a mildew that he had found on most of the plants in an acre of *Valeriana officinalis* grown in Hertfordshire. Numerous cleistocarps of *Erysiphe Cichoracearum* DC. were present on the affected leaves. There was no sign of a perfect stage on the corn salad, and the mildew can conveniently be identified with *Oidium Valerianellae* Fuckel (*Symb. mycol.* 1869, p. 358), which has been recorded on *Valerianella carinata* in Germany and Italy and on *V. Morisonii* in Germany. Lindau, in Rab. *Krypt. Fl.* I, viii (1904), p. 87, suggested that this species may be merely a form of *Oidium erysiphoidea* Fr., which is listed in Oudemans' *Enum. Syst. Fung.* IV, 853, on several species of *Valerianella*, including *V. olitoria*. Blumer (1933) has also given a number of European localities for the *Oidium* stage of what he believed to be *Erysiphe communis* (Wallr.) Fr. on *Valerianella olitoria* Poll., *V. dentata* Poll. and *V. rimosa* Bast., including two records listed by Salmon (1900) under *Erysiphe Polygoni* DC. but not verified by him.

26. Mildew (*Oidium* sp.) on *Schizanthus*

There are only two or three records of a powdery mildew on *Schizanthus* and apparently none from outside Britain. In December 1934 a species of *Oidium* was observed on the leaves of one or two plants in a small greenhouse at the Plant Pathology Laboratory, Harpenden (Moore, 1943). The

mildew was very slight, difficult to detect, and was causing no damage. It was not seen in England again until April 1945, and I am indebted to Mr N. C. Preston for specimens of an *Oidium* which he then found on *Schizanthus* in flower in a private greenhouse at Sutton Coldfield, Warwickshire. The attack was a severe one and the lower leaves had been killed. The *Oidium* was present in quantity, but there was no sign of cleistocarps: the barrel-shaped conidia measured 19–34 × 11–16 μ (average of twenty conidia 25·8 × 12·8 μ) in the dry state. The mildew reappeared in the same greenhouse in the spring of 1946.

Erysiphe Cichoracearum DC. has been listed on this host from the Forth area of Scotland (Dennis & Foister, 1942), but Dr Foister has informed me in a letter that in the absence of confirmatory evidence he would prefer this record to stand as *Oidium* sp.

27. Leaf spot (*Cercospora depazeoides* (Desm.) Sacc.) of Elder (*Sambucus nigra* L.)

In September 1941 Dr Alex Smith and I found a leaf spot causing partial or complete defoliation of many rather small shrubs of elder (*Sambucus nigra* L.) in a comparatively open oak-beech wood at Symonshyde, near Harpenden. The spots were numerous, visible on both sides of the leaves, and mostly 2–5 mm. across. They were rounded, or bounded by the secondary veins and then irregular, uniformly dull grey when small, later becoming bleached dirty white or pale brown, usually with a dull grey border. On many leaves the spots had coalesced, but the darker margins of the original spots remained as grey lines running in wavy patterns over the affected areas. Conidia of *Cercospora depazeoides* (Desm.) Sacc. (*Nuovo G. bot. ital.* viii (1876), 187, syn. *Exosporium depazeoides* Desm. in *Ann. Sci. nat.* (3), xi (1849), 364) were present on both sides of the spots, though more freely produced on the lower surfaces. They measured 50–147 × 4–6 μ (average of twenty-five spores 89 × 4·9 μ) and showed 1–6 transverse septa.

The following month the disease, which had apparently not been recorded previously in Britain, was observed a few miles away at Wheathampstead (Herts), and Dr H. B. S. Montgomery sent me specimens from woods near East Malling (Kent), where the disease was causing complete defoliation of some of the trees. It was also found during a foray at Cooper's Hill (Surrey) in September 1942 and is perhaps not uncommon in England.

28. Black rot of anemone (*Sclerotinia tuberosa* (Fr.) Fuckel)

This disease was carefully studied by Wakker (1889) in Holland, and fifty or sixty years ago it was a subject of frequent correspondence in the English gardening press (*Gdnrs' Chron.* 1886–1903), but very little has been heard of it during the past thirty years. Black rot shows certain unusual and interesting features. It attacks the native *Anemone nemorosa*, but has been found in the past mainly in gardens and rockeries on cultivated varieties of *A. nemorosa*, as well as on *A. coronaria*, *A. apennina*, *A. blanda* and *A. ranunculoides*. It may be destructive to pot plants (Burchard, 1929), but is

seldom seen in commercial plantations. It has not yet been recognized, for instance, in field crops in Cornwall where over 700 acres were devoted to Du Caen and St Brigid anemones in 1938. This is perhaps the more surprising because the large sclerotia of *Sclerotinia tuberosa* so closely resemble the corms of *Anemone coronaria* that it is very difficult to separate them. Although very destructive, the disease has attracted most attention because of the extraordinary abundance of the coffee-coloured apothecia produced from the sclerotia in April and May. As many as forty apothecia may arise from a single sclerotium (Thomas, 1902), and W. G. Smith (1887) wrote: 'when this fungus grows in Anemone beds in gardens it does not grow in single examples; it grows in hundreds, or, in large flower-beds, it sometimes appears in thousands of examples.' In the only recorded outbreak of black rot in this country in recent years (May 1933) very large numbers of apothecia appeared at Harborne, near Birmingham, in a rock garden where few of the anemones escaped attack.

A fresh phase of the disease came to light in October 1941 when I received from a nursery at Taplow (Bucks.) some rhizomes of *A. nemorosa* var. *Robinsoniana* which had been completely destroyed by *Sclerotinia tuberosa* during storage. They had been lifted the previous August and stored in bulb trays kept in racks in such a way as to permit good ventilation. As usual, the rhizomes had been buried in peat in the trays to prevent them from shrivelling. When examined on 10 October the long, thin, light brown, stick-like rhizomes were still fresh and healthy in several of the trays, but in two trays there remained nothing but a congealed mass (Pl. XV, fig. 1) consisting of discoloured brittle fragments of rhizomes and a number of the large black sclerotia characteristic of *S. tuberosa*, the whole being matted together and enveloped in a loose weft of white mycelium. In a third tray the rot was just beginning. It seems very probable that a few of the rhizomes were slightly affected with black rot before they were put into the trays. The sclerotia were black, irregular, rounded, hard bodies up to $1\frac{1}{4}$ in. across and nearly $\frac{1}{2}$ in. thick (Pl. XV, fig. 2), white inside, and consisted of a mass of interlacing hyphae 4–6 μ wide, surrounded by a narrow black rind 15–40 μ thick. A few of them were placed in a pot of soil and left outside during the winter but, as is apparently not unusual, no apothecia appeared the following spring.

S. tuberosa is closely allied to *S. bulborum* (Wakk.) Rehm, the cause of black slime of hyacinth and *Scilla*, but its sclerotia are much larger, the apothecia are produced much more freely and have larger, deeper brown discs, and there are other slight morphological differences. Moreover, the fungus on hyacinth will not attack anemone and that on anemone apparently will not infect hyacinth.

29. A virus disease of Cos Lettuce (Dandelion Yellow Mosaic Virus)

Kassanis (1944) proved that a virus which commonly produces chlorotic rings and spots on dandelion leaves is also the cause of a lettuce disease that had been observed in different parts of England during the previous three years. He briefly described the symptoms artificially induced in glasshouse

lettuce by this virus, for which he suggested the name dandelion yellow mosaic virus.

A disease, later shown by Dr Kassanis to be caused by this virus, appeared in mid-July 1942 on some Cos lettuce plants (variety Balloon) which had been raised under glass and pricked out for summer use in two adjacent gardens in Harpenden. It was seen first in one small clump in my own garden, at a time when the healthy plants were just beginning to heart, and by the end of the month it was present in several other clumps not many feet away, but developed in only one plant in the adjacent garden. The visible effect on the plant was not always the same, and appeared to vary with the time at which infection took place.

Several plants, evidently infected when quite young, were only 6 in. instead of a foot high (Pl. XVI, fig. 3). The outer four or five leaves were small but otherwise normal, with no obvious mottling or chlorosis. The next inner leaves were small and narrow, crimped or puckered, and showed a marked general necrosis which began as minute, rather angular, pale brown interveinal dots that later coalesced to give patterns of dark brown, grey-brown or almost black tissue immediately bordering the veins, even the finest ones (Pl. XVI, fig. 4). The necrosis was often particularly noticeable in the middle part of the leaves. The margins of some leaves were wilting or even withered, while in other leaves the tips and sometimes the margins for $\frac{1}{2}$ cm. inwards had a burnt appearance. The youngest leaves showed no visible necrosis.

Infected plants with outer leaves green, turgid, and a foot long, showed rather different symptoms, though it was always the next inner leaves which were mainly affected. Sometimes these leaves were pale and partly withered from the tips or margins inwards. The tissues were then brown, dry and papery, or the interveinal areas had fallen out, leaving holes. The veins usually showed a marked brown or black streaking. In other plants there were a few scattered inconspicuous pale brown areas on the outer mature leaves, while the next inner ones showed only a local or diffuse and rather ill-defined necrosis, the most prominent symptom being a ladder-like brown fretting of the outer, and occasionally the inner, surface of the main and lateral veins. The youngest leaves rarely showed more than a faint necrosis.

It is highly probable that this lettuce disease has been present in England for some time. Salmon & Ware (1934) referred to the occurrence of an unidentified disease in Balloon lettuce at Lancing (Sussex) and in the Cos variety, Mammoth White, at Scaynes Hill (Sussex) in July 1933, while specimens of a similar attack in black-seeded Balloon lettuce were received from King's Lynn in September 1938. Photographs and information about these cases, filed at the Plant Pathology Laboratory, strongly suggest that this virus disease was involved. Since 1942 it has been observed by Mr L. Ogilvie at Long Ashton, Somerset (July 1945) and by Mr H. H. Stirrup in a number of outdoor crops in the Kesteven area of Lincolnshire (June 1946). Dandelion yellow mosaic virus has been transmitted artificially by *Myzus ornatus* Laing, *M. pseudosolani* Theob. (Kassanis, 1944), and *M. ascalonicus* (Doncaster & Kassanis, 1946), but not by *M. persicae* Sulz.

30. Lettuce Rust (*Puccinia Opizii* Bubák)

Towards the end of May 1930, during a special examination in the London markets of lettuces imported from Holland, rust was found in very small quantity on the outer leaves of several plants. Only about a dozen rust spots were seen altogether. Each was about ½ in. across and consisted of clusters of aecidia and spermogones. There was no hypertrophy of the tissues. The same rust, which was identified at the time as *Puccinia Opizii* Bubák (Pethybridge, Moore & Smith, 1934), has since been observed on two other occasions in lettuce imported into this country from Holland. A small quantity was seen on the London market in June 1932, and in May 1946 a few aecidia were found by Mr R. N. Swanton on the outer leaves of lettuces in four out of ten crates examined on the quayside at Newcastle-on-Tyne. It has not yet been observed occurring naturally on either wild or cultivated lettuce in Great Britain.

There are two aecidial forms on wild species of *Lactuca* in Europe. One is a stage of the autoecious rust, *Puccinia Chondrillae* Corda (also called *P. Prenanthis* (Pers.) Lindr. and *P. Lactucarum* Syd.), which is found, probably in specialized forms, on *Lactuca muralis* and *L. perennis*. This aecidium has a poorly developed peridium and causes slight hypertrophy of the leaf veins. The other is a stage of the heteroecious rust, *Puccinia Opizii* Bubák, with its aecidia on various species of *Lactuca*, *Crepis*, *Sonchus*, and on *Lapsana communis*, and its uredospores and teleutospores on *Carex muricata*. The aecidia have a complete and well-developed peridium and form larger spots, with no hypertrophy of the leaf tissues.

Bubák (1902) erected the name *Puccinia Opizii* when he showed experimentally that *Aecidium lactucinum* Lagerh. & Lindr. on *Lactuca muralis* and *L. scariola* belonged to the life cycle of a *Puccinia* on *Carex muricata*. Later, Tranzschel (1909, 1914) and Mayor (1920) proved that the rust on *C. muricata* can develop its aecidia on other species of *Lactuca*, including *L. sativa*, as well as on *Lapsana communis* and several species of *Crepis* and *Sonchus*.

Puccinia Opizii is still comparatively rare on cultivated lettuce in Europe and appears to be more or less innocuous. In Germany it was recorded in 1892 near Berlin, under the name *Aecidium Lactucae-sativae* Syd. (Sydow, 1924), and has also been observed in Brandenburg (Pape, 1926) and the Rhineland (Poeverlein, 1940). Poeteren (1933) has referred to its occasional occurrence on lettuce in Holland and there are records of it from Poland (Siemaszko, 1929) and Rumania (Săvulescu, Sandu-Ville, Rayss & Alexandri, 1934).

The aecidium occasionally found on lettuce in North America appears to be a different one. Arthur (1912) produced aecidia on *Lactuca sativa* and *L. canadensis* with a *Puccinia* from *Carex siccata* Dewey which he called *Puccinia Opizii* Bubák, but Kern (1917) concluded that all the American forms of rust with aecidia on the closely related genera *Adopogon*, *Agoseris*, *Crepis*, *Lactuca*, *Hieracium* and *Prenanthes*, and with uredospores and teleutospores on various species of *Carex*, including *C. siccata*, belonged to the same species, and one which was not identical with the European species. He

accepted for it the name *Puccinia patruelis* Arthur (1909), syn. *P. Opizii* Arth. non Bubák and *P. extensicola* Plowr. var. *hieraciata* (Schw.) Arth. This rust has been recorded on cultivated lettuce from seven Canadian provinces (Crowell & Lavalee, 1942) and in small amount from North Dakota (Sprague, 1945). A rust has also been listed on lettuce in New South Wales (Noble, Hynes, McCleery & Birmingham, 1934) under the name *P. prenanthis* (Pers.) Lindr.

31. Radish Canker (*Corticium Solani* (Prill. & Delacr.) Bourd. & Galz.)

Corticium Solani, in its mycelial stage *Rhizoctonia Solani* Kühn, is a common cause of damping off, wire stem, and other disease symptoms in many different kinds of plants, including crucifers. It sometimes attacks radishes, and on this host most frequently produces blackish, canker-like areas on the maturing 'root', which have been illustrated abroad by Gloyer & Glasgow (1924), Chupp (1925), and Weber (1932).

Radish canker has been observed only a few times in Britain. It was first recognized on specimens received at Harpenden in June 1928 from a farm at Taplow, Bucks. *Corticium Solani* was isolated in pure culture and the blackish rot was reproduced by inoculation into the few rather old and stringy radishes that were then available. The same month a disease that was very similar in appearance proved rather serious and destructive in a market garden crop of long red radishes near Preston, Lancs., but no mycelium could be found in the rotted tissues and attempts to isolate *C. Solani* were unsuccessful. In June 1935 the disease was reported to have developed in patches in two farm crops on sandy soil at Mortlake (Surrey) and on heavier soil at Bedfont (Middlesex). Specimens received from Mortlake showed dark, soft, canker-like lesions on the sides or towards the top of the swollen edible portion of the root and no difficulty was experienced in isolating *C. Solani* from the advancing margin of the rotted tissue, which contained an abundance of mycelium. When healthy radishes were inoculated with the fungus from pure culture and were placed under moist conditions, rotting set in after a day or two and progressed so rapidly that within a fortnight only the discoloured skin and part of the vascular network remained more or less intact. Naturally infected radishes ultimately rotted in the same manner. Mr W. Buddin, who visited the farm at Mortlake, estimated that no more than one plant per thousand was affected, but this was sufficient to spoil the appearance of the bunches, and it was not possible to discard the affected radishes, partly because the lesions often escaped detection until the roots were washed. Mr Buddin also visited the farm at Taplow where canker had been seen seven years before and he had no difficulty in finding the disease; it was said to occur there every year but to cause no serious trouble. Too frequent cropping with radishes was thought to be a predisposing factor.

Preliminary tests indicated that strains of *C. Solani* isolated from potato would not infect radish. The radish strain failed to infect carrots, parsnips, mangolds and potatoes inoculated late in July and kept under moist con-

ditions, but white turnips and radishes inoculated the same day were completely rotted by mid-August. These results were later confirmed and extended by Storey (1941) who tested thirteen strains of *C. Solani* from various hosts and found that those from cruciferous plants were restricted in their attack to cruciferous hosts. His radish strain, derived from Harpenden, did not attack lettuce, potato or tomato, but fairly readily infected seakale, swede and seedlings of stock (*Matthiola*).

Gloyer & Glasgow (1924) have reported effective control of radish canker by several applications of acidulated mercuric chloride.

32. Seedling Disease of Flax (*Alternaria linicola* Groves & Skolko)

On 9 June 1942 Mr W. Buddin sent me some diseased flax seedlings about 6 in. high, which had been taken from a field of linseed at Binsted, Hampshire. The same trouble also occurred in a field on a second farm sown from the same bulk of untreated seed.

At first sight the seedlings appeared to be healthy except for the cotyledons, which were brown and withered and fell off at a touch (Pl. XVII, fig. 5). Most of the affected cotyledons were partially or wholly blackened owing to the presence on them of numerous tufts of conidiophores and conidia of a species of *Alternaria* with long-beaked spores. Closer examination revealed that on some seedlings there were minute dark spots on the first pair of foliage leaves above the cotyledons. The spots spread irregularly to give necrotic areas 1–2 mm. across, and on a few seedlings this pair of leaves was completely discoloured and shrivelled. There was also an occasional pale brown streak on the stem just above the cotyledons and more frequently a scarcely perceptible shallow, canker-like area on the hypocotyl or at the base of the main root. The rim of the canker was reddish brown, and reddish brown streaks extended from it upwards into the hypocotyledonary region. The *Alternaria* was successfully isolated in pure culture from the cotyledons and from some of the minute spots on the foliage leaves, but not from the roots. It is undoubtedly the same species as the recently described, seed-borne fungus *A. linicola* Groves & Skolko (1944), syn. *A. linicola* Neergaard (1945). In the thirty spores measured the spore body was 30–100 μ long and 11–27 μ wide (average 65 × 16 μ), with 4–11 transverse septa. The beak was 15–135 μ long (average 60 μ) and the total length of the spores 60–235 μ (average 125 μ). Dr Mary Noble has informed me that in 1945 she found *A. linicola* Groves & Skolko on flax seed at Edinburgh, and later obtained it from seedlings in two fields in Perthshire sown with the infected seed.

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EXPLANATION OF PLATES XV–XVII

Fig. 1. Stored rhizomes of *Anemone nemorosa* var. *Robinsoniana* destroyed and matted together with mycelium and sclerotia of *Sclerotinia tuberosa*.
Fig. 2. On the left a rhizome of *Anemone nemorosa* var. *Robinsoniana* killed by *Sclerotinia tuberosa*: on the right a single sclerotium of the fungus.
Fig. 3. Dwarfed lettuce plant infected with dandelion yellow mosaic virus.
Fig. 4. A single infected lettuce leaf showing interveinal necrosis.
Fig. 5. Flax seedlings showing cotyledons and first foliage leaves attacked by *Alternaria linicola*.

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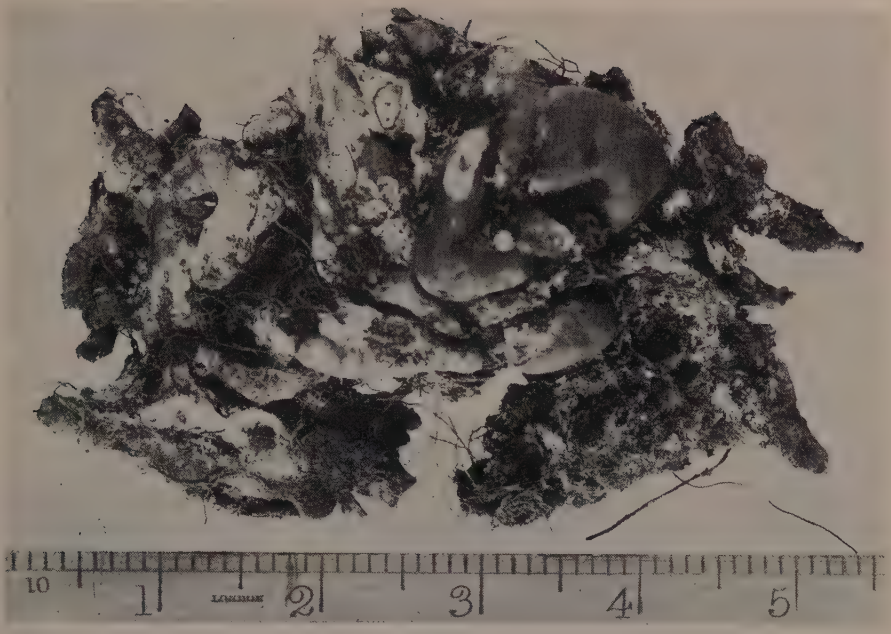

Fig. 1.

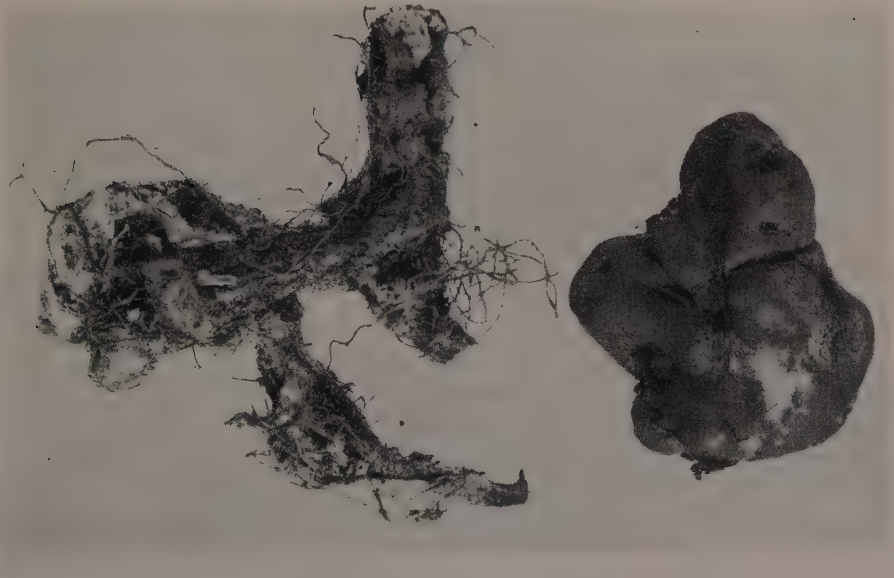

Fig. 2.

Fig. 3

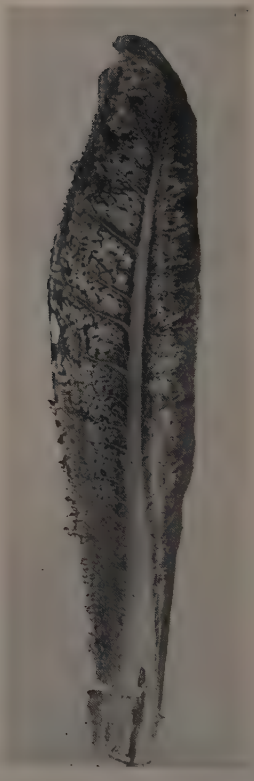

Fig. 4

Fig. 5

REVIEWS

The Mycetozoa of North America, based upon the specimens in the Herbarium of the New York Botanical Garden. By ROBERT HAGELSTEIN, Honorary curator of Myxomycetes. New York: Robert Hagelstein, 165 Cleveland Avenue, Mineola. 1944. Cloth, 306 pages, four colour plates and twelve in half-tone. Price $6.00.

The Mycetozoa have attracted many students in North America, and no doubt its vast terrain, with large stretches of forest and swamps, and wide range of climatic conditions form admirable grounds and supply habitats for a large number of species of this interesting group.

The Mycetozoa of North America is a welcome addition to the literature of these organisms and is the result of a great amount of field work by the author and his associates over a period of twenty years. They have studied in the field and collected more than ten thousand developments. In addition, as curator of the Myxomycetes in the Herbarium of the New York Botanical Garden, Mr Hagelstein has had access to a large amount of material collected by earlier workers on the group in his own country and also that donated by workers in many parts of the world.

It is interesting that he has adopted the name Mycetozoa in preference to that of 'Slime Moulds' used by previous North American writers, and thus comes into line with the term used in this country and elsewhere.

The book describes 285 species and fifty-one varietal forms found in North America and thus deals with most of the Mycetozoa of the world. Only thirty-three species are quoted as not having been found in that country. It is well printed in good clear type and contains four coloured plates; the author refers the reader for all other illustrations to the British Museum *Monograph of the Mycetozoa*, Lister, 3rd ed., which cannot be surpassed. The plan of printing the names of species in heavier type than the synonyms is to be commended and facilitates reference. In addition, there are a number of plates in half-tone made from photographs by the author. It is not easy to produce good photograhic records of Mycetozoa and in my opinion some of the sporangia could well have been shown larger and with more depth of focus.

The introduction is very good, and it is interesting to learn that fruiting usually takes place at night. The instructions to would-be collectors are very helpful, but I prefer to use somewhat deep tin boxes with a sheet of cork fastened to the bottom, especially when a gathering is made of a species whose development is not completed. The substratum on which the species is forming is usually moist and there is less risk of quick drying in a tin than in a cigar box lined with corrugated paper.

Mr Hagelstein does well to emphasize the fact that the group provides great opportunity for research in morphology, physiology and taxonomy; there are several problems yet unsolved. In the glossary a plasmodium is defined as 'a mass of naked protoplasm formed by the union of many swarm cells which latter emerge from the spores on germination'. This definition requires considerable qualification, the plasmodium being actually formed from amoebulae which unite in pairs as gametes to form zygotes. It is these zygotes which, after feeding, develop into plasmodia. However, in the introduction, this phase of life history is more clearly explained.

With regard to taxonomy, the author's descriptions are extremely well done and his judgements are very sound. One would have liked to have known more of the seasonal distribution of many species.

Some changes have been made from the previously accepted nomenclature in Lister, 3rd ed. Mr Hagelstein, strictly following the International Rules of Nomenclature, according to which a synonym must not be used again on any fresh association, substitutes *Physarum Listeri* Macbr. for *P. luteo-album* Macbr., as *P. luteo-album* Schumacher is now considered to refer to *Perichaena corticalis* (Batsch) Rost. For a similar reason *Physarum Bilgramii* replaces *P. lilacinum* Sturgis & Bilgram, as *P. lilacinum* Fries (1829) is now *Badhamia lilacina* Rost. *P. Wingatense* replaces *P. columbinum* Sturgis, and similarly

Didymium anomalum appears as *D. Sturgisii*. Since Miss Lister agrees that the genus *Trichamphora* is somewhat artificially separated from the unwieldy genus *Physarum*, the change of *Trichamphora pezizoidea* Jungh. to *Physarum pezizoideum* appears to be justified.

It is of interest that whereas *Physarum carneum* G. Lister & Sturgis occurs on dead wood and twigs in North America, I found it for four years always under dense bramble thickets upon bramble stems and dead bracken.

Physarum notabile Macbr. (syn. *P. connatum* List.) is a fine example of Mr Hagelstein's critical work in the determination of a species, and the same remark applies to his analysis of other groups of allied species, e.g. *Lepidoderma Carestianum*, its var. *granuliferum*, and *L. Chailletii*.

In giving some varietal forms specific rank, as in the separation of *Stemonitis trechispora* Torrend (Macbr.) from *S. fusca*, because it has an extremely wide range of capillitium and spores, and a different habitat, is it necessary to separate it from *S. fusca*? Is it not possible, as the author stresses in his conclusion, that the varietal forms here and elsewhere may be due to a change of habitat, just as differences of temperature appear to cause a species to diverge from its typical form? The same remark appears to apply to the separation of the two varietal forms of *Didymium nigripes* Fries, giving them specific rank as *D. eximium* and *D. xanthopus*. Miss Lister states that these have been distinguished by specific names, but says that the variation in colour of capillitium, stalk, and columella occurs in the same group of sporangia and that they seem to blend into one another so completely as to represent one species. Both the type form and var. *xanthopus* have been frequently met with by me in Norfolk and elsewhere and there does not seem sufficient reason for their separation. Mr Hagelstein himself states that somewhat reluctantly he has treated the three as distinct species and admits that they seem to occur when wet and moist conditions of habitat are reversed.

Stemonitis ferruginea Ehrenb. has been discarded in favour of *S. axifera* (Bull.) Macbr. in spite of the reasoned argument of Miss G. Lister (in Lister, 3rd ed.), in favour of its retention. Mr Hagelstein admits that *Comatricha aequalis* Peck, to which he gives specific rank, is practically the same as *C. nigra* Schroet., with similar capillitium and spores, differing only in the larger sporangia. He further states that many students have considered it as a varietal form of *C. nigra* and with some reason, as it is not common and occurs only occasionally where that species is abundant. It therefore seems difficult to understand why he separates it from *C. nigra* var. *aequalis* Sturgis as in (Lister, 3rd ed.)

Enerthenema papillatum Rost. has been split up into three species, the type form *E. papillatum* Rost., *E. melanospermum* Macbr. & Martin, and *E. Berkeleyanum* (Rost.) var. *syncarpon* (Sturg.) G. Lister. The author doubtless had access to several gatherings and he states that the three species are sharply defined.

In dealing with *Lamproderma atrosporum* Meylan, the typical form of which has not been recorded from Britain, the varietal forms var. *anglicum* G. Lister & Howard and var. *debile* G. Lister & Howard are omitted, not having been found in U.S.A., but the author suggests that they are intermediate forms connecting the species with *L. cribrarioides* and *L. Gulielmae*. I would like to point out that both forms were gathered in 1918, 1920, 1922, and 1923 on dead beech and box leaves under clumps of *Buxus sempervirens* in precisely the same spot by me, and Mr E. Brazier also found them on beech leaves in Worcestershire. *Lamproderma cribrarioides* has been recorded only from Aberdeenshire and typical *L. Gulielmae* has only once been recorded from Norfolk by me. The fact that the two varietal forms were met with over a space of five years seems to negative any idea that they must have been due to climatic conditions during development.

Macbrideola scintillans Gilb. n.gen. found on bark of living trees is an interesting addition to the list of arboreal species so well studied by the late Rev. Cran in Scotland. *Elaeomyxa myazakiensis* (Emoto) Hagelstein, found in Japan, adds a new genus to the Mycetozoa.

In dealing with *Cribraria aurantiaca* Schrad., the author quotes the plasmodium as green or slate-grey (Lister). In 3rd ed. Miss Lister gives the colour of the plasmodium of *C. vulgaris* Schrad. (1797) as usually slate-grey, whereas in var. *aurantiaca* Pers. (1801) it is green. Both forms have been seen in all stages by me in abundance on coniferous wood, and by the rules of priority *C. vulgaris* should be the name for the species and *C. aurantiaca* (as stated in Lister, 3rd ed.) with longer stalks, golden-yellow spores when fresh, and maturing from bright green plasmodium should be given varietal rank.

Cribraria microcarpa (Schrad.) Pers. as found in Europe represents a form different from that found in N. America; might not this be true of other species whose specific rank has been challenged? In Lister, 3rd ed., *Orcadella parasitica* (Zukal) Hagelstein (1942) appears as *Hymenobolina parasitica* (Zukal). The similarity of habitat on dead bark, mosses, lichens, and its general character seem to justify its inclusion in the genus *Orcadella*. The same justify the transfer of *Kleistobolus pusillus* Lipp. to the genus *Orcadella*, especially in view of the large amount of material which was available for examination. In his description of *Arcyria cinerea* (Bull.) Pers. var. *digitata* (Schw.) G. Lister, Hagelstein includes the varietal form but states that it is hardly worth recognition as a variety, much less as a species. I have made many gatherings of this common species in the type form, but as the variety appears to be confined to the tropics, where it is abundant, I think Mr Hagelstein does well to retain it as a definite variety.

Arcyria magna Rex. has been given specific rank. In Lister, 3rd ed., it is regarded as a form of *Arcyria Oerstedtii* Rost.; possibly in view of the number of gatherings both of *A. Oerstedtii* and *A. magna* in North America, the separation may be justifiable in spite of the fact that *A. magna* does not occur in any particular area.

The book concludes with a very comprehensive bibliography, and the author is to be congratulated on having produced a work which should attract many more students to the study of a fascinating and interesting group and which can be regarded as the standard work upon the Mycetozoa of North America.

It is with deep regret that shortly after this review was written the news came that Mr Hagelstein died on 20 October 1945. His passing represents a great loss to the somewhat small band of workers throughout the world on the group to which he devoted so much time and painstaking work.

H. J. Howard

The Aquatic Oomycetes of Wisconsin. Part I. By Frederick Taylor Wolf, Vanderbilt University. (Madison: The University of Wisconsin Press, 1944.) 64 pp., 6 plates. Price $1.50.

Dr Wolf writes in the opening words of his introduction: 'Of all the aquatic fungi, perhaps none are more common or widely distributed than those of the family Saprolegniaceae.' It is because of the wide distribution of these and other 'Water Moulds' that this book, intended primarily for Wisconsin students, is of more than local interest, and workers in this field of study are indebted to Dr Wolf for the list of aquatic oomycetes given with useful keys and short, clear descriptions of each order, genus, and species, for which descriptions he acknowledges the value to him of Coker's monograph on the Saprolegniaceae.

The book opens with an interesting historical survey beginning even before the researches of de Bary. Then follows the list of species grouped in the Lagenidiales, Blastocladiales, Monoblepharidales, Saprolegniales, Leptomitales, and Pythiales.

Where one would like to enter into discussion with Dr Wolf about his book is on questions of taxonomy. Why, for instance, does he, himself a student of the Blastocladiales, include this order among 'Oomycetes', an order in which the oospore is conspicuous only by its absence and where the characteristic resting sporangium is the dominating feature? It is true he states that his key to the orders is 'after Fitzpatrick, 1930', but Prof. Fitzpatrick would be the first to disclaim it now, on the basis of work published since 1930. Again, why are the Lagenidiales separated from the Saprolegniales by the Monoblepharidales? Since 1930, Dr Sparrow has published an acceptable re-grouping of these orders on the character of the flagellum (which Dr Wolf still calls the cilium). Again, the only reference to *Phytophthora* in the book is on p. 44 in brackets: '(*Phytophthora*, a non-aquatic genus, has conidia [*sic*] which may either release zoospores or germinate by germ tube).' The explanation of this omission is to be found on p. 49 under *Pythiomorpha*: 'Buismann (1927) proposed to unite this genus with *Phytophthora*, and in this he [*sic*] was followed by Fitzpatrick (1930). We prefer, however, to follow Kanouse and retain *Pythiomorpha* as a valid genus of the Pythiaceae.' The insecurity of this argument is evident in the description of *Pythiomorpha Fischeriana* which runs: 'Sexual organs were not observed, but the asexual structures easily [*sic*] served to

identify the fungus. The cymose mycelium and conspicuous apically-papillate sporangia are quite distinctive.' Evidently all the *Phytophthora*-like aquatic fungi found in Wisconsin will be named as species of *Pythiomorpha*.

The illustrations have the value of diagrammatic drawings in their clear outline and emphasis upon essentials, but some of their disadvantages too. For instance, in figures of the species of *Pythiomorpha*, those supposed diagnostic characters of papilla and sporangiophore are omitted. By the way, the shape of this sporangium is ob-pyriform not pyriform.

But, in spite of these criticisms of taxonomy, terminology, and illustration, the value of the straightforward account of species found and identified cannot be questioned. A later edition will give opportunity for correction of a few minor errors in the text, and, it is hoped, may include additional ecological data.

This slim volume is attractively produced by the University of Wisconsin Press. The neat shape and size and the good print on good paper make the book very pleasant to hold and read. And the lettering on the spine is the right way up when the book lies on its back on the table.

E. M. Blackwell

THE TWENTIETH ANNUAL PLANT PATHOLOGY FIELD DAY

By invitation of Dr J. Grainger the Twentieth Plant Pathology Field Day was held in the Department of Plant Pathology, West of Scotland Agricultural College, Auchincruive by Ayr, on Saturday, 29 June 1946. About forty members were present in the Plant Pathology Laboratory at 10.30 a.m. when Dr Grainger welcomed the Society and gave an interesting talk, illustrated by exhibits, on the work that his Department was doing on the relation between climatic conditions and plant diseases. After an animated discussion on this subject Mr H. F. Dovaston gave an account of his investigation of *Fusarium* Foot Rot of Cereals, with particular reference to the influence of external conditions on the pathogenicity of the species of *Fusarium* he was studying. Members then paid a brief visit to some of the experimental plots near the laboratory and spent further time in examining the exhibits. Dr Grainger commented on demonstrations which illustrated problems that had arisen from advisory work, and Mr Booth described the work he had begun on frost damage in that area.

The members were the guests of the Governors of the West of Scotland Agricultural College at lunch. After lunch the Chairman of the Plant Pathology Committee, Mr W. C. Moore, thanked the Governors and Prof. Walton for their kind hospitality and expressed the appreciation of the Society to Dr Grainger and his colleagues for arranging such an interesting programme. He also specially welcomed to the meeting the Rev. Robert Barr, whose association with the Society went back to its earliest years.

Members then moved to the Horticultural Department where Mr R. D. Reid described his work on the breeding of strawberry varieties resistant to Red Core (*Phytophthora Fragariae* Hickman). This was followed by a lively discussion after which, in spite of heavy rain, some members visited Mr Reid's field plots while the remainder examined the strawberry plots near the Department. After tea and more informal discussion at the Hostel the members dispersed at about 4.30 p.m.

H. E. Croxall, *Secretary*
Plant Pathology Committee

NOTICE

Dr R. K. S. Wood, of the Imperial College of Science and Technology, South Kensington, London, S.W. 7, would be grateful to receive samples of mouldy paint from any source, together, where possible, with details of the kind of paint, location of painted surface, and approximate atmospheric conditions (greenhouse, bakery, brewery, etc.), and the address of the sender.

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